Mineral Development Division
Department of Mines and Energy
Government of Newfoundland and Labrador

CURRENT RESEARCH

Report 81-1

C.F. O'Driscoll and R.V. Gibbons (Editors)

St. John's, Newfoundland
1981

Editor R.V. Gibbons

Review Geologist C.F. O'Driscoll

Text editing and typesetting
D. Downey
B. Doyle
T. Parsons

Typing

C. Gullage
E. Hutchings

Drafting Supervisor

K. Byrne

Drafting

W. Howell
D. Leonard
T. Paltanavage
W. Clarke

Acknowledgements

This report contains papers on geoscience activities of the staff of the Mineral Development Division during the 1979 season. Reports 9, 24 and 25 (as numbered in the table of contents) and the one by Collins and Burt describe work funded by the Government of Newfoundland and Labrador. All other reports describe work done under the Canada-Newfoundland Mineral Development Subsidiary Agreement (1976-1981). This agreement consists of a 5-year program supported by funds provided by the federal Departments of Energy, Mines and Resources (45%) and Regional Economic Expansion (45%) and by the Government of Newfoundland and Labrador (10%).

Publications of the Mineral Development Division are available through the Publications and Information Section, Mineral Development Division, Department of Mines and Energy, P.O. Box 4750, St. John's, Newfoundland. A1C 5T7
Telephone: (709) 737-3159
Telex: 016-4724

Mineral Development Division
Department of Mines and Energy
Government of Newfoundland and Labrador

CURRENT RESEARCH

Report 81-1

C.F. O'Driscoll and R.V. Gibbons (Editors)

LEGISLATIVE LIBRARY
WITHDRAWN
LEGISLATIVE LIBRARY OF ONTARIO
TORONTO
JUN 04 1981
RECEIVED

St. John's, Newfoundland
1981

101-05123/

PREFACE

This publication is the eighth in a series of annual Reports of Activities in which the Mineral Development Division summarizes results of its projects in progress.

During the past year the field activities carried out by the Division under the Canada-Newfoundland Mineral Development Subsidiary Agreement reached a peak; some 23 field parties were active, with a total budget in excess of three million dollars. Much of this effort concentrated on regional geological mapping (reports 1-20). Field work was completed on long term mapping projects in the Davis Inlet area, the Red Wine Mountains, the Deer Lake Basin, the Victoria Lake area, and the Burin Peninsula. The Labrador Mapping Section began a concentrated effort in the Grenville Province, using large helicopter supported field parties. This effort, when combined with earlier work in the Red Wine Mountains and Hamilton Inlet areas, will provide complete 1:100,000 mapping across the northern part of the Labrador Grenville, from the Quebec border to Sandwich Bay, and a base from which to move farther south into Grenville Province. The Newfoundland Mapping Section continued its program aimed at 1:50,000 coverage of the island portion of the Province.

The Geochemistry Section continued its regional lake sediment survey program, this year completing the northeastern section of Newfoundland; in Labrador, the section concentrated on more detailed studies to follow up previously reported regional work. Data from the northeast Newfoundland regional survey will be released in the spring of 1981; the results of the detailed work in Labrador, which resulted in the discovery of uranium mineralization, were released in the fall of 1980.

The Mineral Evaluation Section saw a number of changes during the year. The section acquired a new senior geologist, was renamed the Mineral Deposits Section, and acquired responsibility for metallogenic studies, as well as industrial mineral surveys and mineral inventory. The industrial mineral assessment moved on from labradorite and other gemstones to investigate building stone and mineral fillers.

The Environmental Geology Section completed its inventory of aggregate resources along transportation corridors in the Province, and continued its investigation of the surficial and glacial geology of the Buchans Volcanic Belt. A study of the glacial geology of the Deer Lake Basin was also completed.

The Publications and Information Section took over the responsibility for the core storage program in 1980. The core storage building at St. John's was completed, a building was acquired at Goose Bay, and plans are in progress for a facility at Pasadena to be built in 1981. Field examination and retrieval of drill core continued with excellant cooperation from the exploration industry.

Next year the Division reaches the end of its current 5-year program of Federal-Provincial cost-shared geoscientific studies - the Canada-Newfoundland Mineral Development Subsidiary Agreement - which has provided the funding for most of the projects described in this publication (all except reports 9,24 and 25). Because of this, many of the projects will concentrate next year on the preparation of final reports for publication rather than on the acquisition of new data. We therefore anticipate a somewhat reduced field program in 1981, a reduction which we hope will be only a temporary interlude before we embark on a major new program in 1982.

B.A. Greene
Director
Mineral Development Division

1981 01 28

Any reader who would like to write a rebuttal to, or discussion of, any report contained in this volume is invited to submit it to the editor by November 1, 1981, to be considered for inclusion in Report 82-1.

CONTENTS

PAGE

I. GEOLOGICAL MAPPING, INSULAR NEWFOUNDLAND

1. **Stouge, S.** Cambrian - Middle Ordovician stratigraphy of Salmon River region, southwest Hare Bay, Great North Peninsula 1

2. **Hyde, R.S. and Ware, M.J.** Geology of Carboniferous strata in the Deer Lake (12H/3) and Rainy Lake (12A/14) map areas, Newfoundland..... 17

4. **Kean, B.F. and Jayasinghe, N.R.** Geology of the King George IV map area (12A/4), Newfoundland..... 32

5. **Colman-Sadd, S.P.** Geology of the Burnt Hill map area (2D/5), Newfoundland..... 40

6. **Blackwood, R.F.** Geology of the West Gander Rivers area, Newfoundland..... 50

7. **Chorlton, L.** Grandys Lake (110/15), Newfoundland..... 57

9. **Smyth, W.R.** Lower Paleozoic geology of southwestern White Bay..... 70

10. **Swinden, H.S.** Economic geology of the western Hermitage Flexure, Newfoundland..... 80

11. **Dickson, W.L. and McLellan, H.E.** Geology of Wolf Mountain (12A/2W) and Burnt Pond (12A/3E), central Newfoundland..... 96

II. GEOLOGICAL MAPPING, LABRADOR

14. **Ryan, B., Neale, T. and McGuire, J.** The geology of the Grand Lake area, Labrador..... 103

15. **Thomas, A., Jackson, V. and Finn, G.** Geology of the Red Wine Mountains and surrounding area, central Labrador..... 111

16. **Gower, C.F., Noel, N. and Gillespie, R.T.** The geology of the Rigolet region, Labrador..... 121

17. **Wardle, R.J. and Britton, J.M.** The geology of the Churchill Falls area, Labrador..... 130

18. **Nunn, G.A.G.** Regional geology of the Michikamau Lake map area, central Labrador..... 138

19. **Rivers, T.** Geological mapping in the Ashuanipi Lake - Lac Petite-Hermine and Rannie Lake areas, western Labrador..... 149

20. **Hill, J.D. and Epstein, R.S.** Geology of the Notakwanon River area, Labrador..... 158

- **Wardle, R.J.** Labrador Geochronology..... 169

III. GEOCHEMISTRY

21. **Butler, A.J.** Reconnaissance geochemical lake sediment program, Terra Nova area, northeast Newfoundland..... 171

22. **McConnell, J.W.** Stream and soil geochemical surveys in Labrador..... 175

IV. MINERAL DEPOSITS

- **Watson, D.M.** Dimension stone and mineral filler assessment..... 179

V. ENVIRONMENTAL GEOLOGY

23. **Ricketts, R.J., Kirby, F.T. and Vanderveer, D.G.** Inventory of aggregate resources..... 182

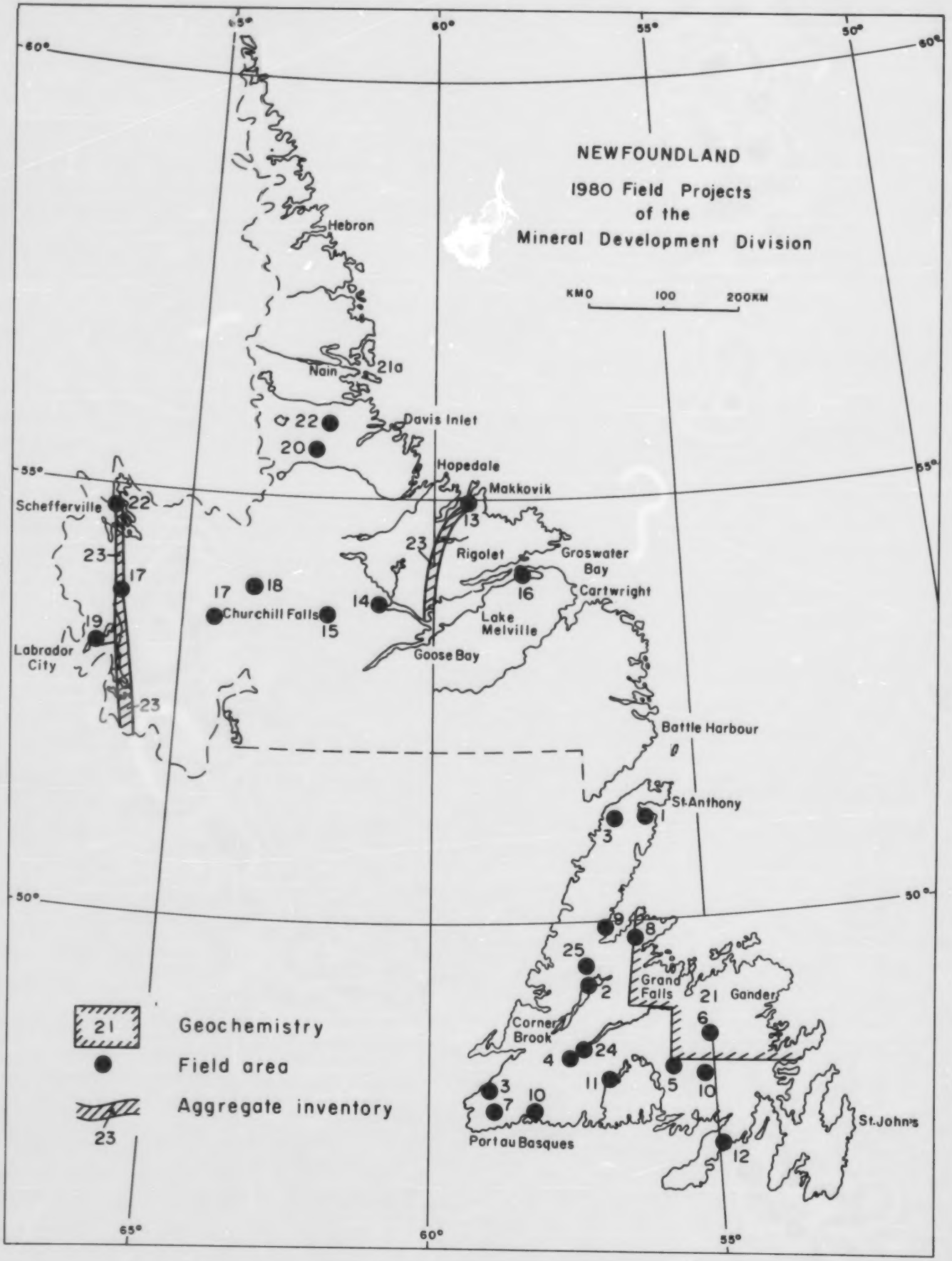
24. **Sparkes, B.G.** Star Lake - Victoria Lake surficial and glacial mapping, Newfoundland..... 188

25. **Vanderveer, D.G.** Quaternary mapping - Upper Humber River area..... 192

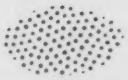
VI. PUBLICATIONS AND INFORMATION

- **Collins, C.J. and Burt, B.** Drill core storage program..... 195

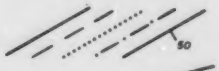
NOTE: The numbers refer to those on the accompanying index map.

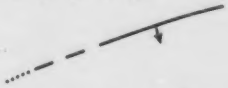

NEWFOUNDLAND
1980 Field Projects
of the
Mineral Development Division
KMO 100 200KM
Hebron
Nain
21a
22
Davis Inlet
20
Hopedale
Makkovik
13
Schefferville
22
23
17
17
18
Churchill Falls
15
19
Labrador City
23
14
23
Rigolet
Groswater Bay
16
Cartwright
Lake Melville
Goose Bay
Battle Harbour
St.Anthony
1
3
9
8
25
2
Grand Falls
21
Gander
Corner Brook
6
4
24
11
5
10
3
7
10
Port au Basques
12
St.John's
21
Geochemistry
Field area
Aggregate inventory
23
65°
60°
55°
50°

LIST OF SYMBOLS USED ON GEOLOGICAL MAPS AND FIGURES

Drift covered area 

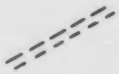
Rock outcrop, area of outcrop, probable outcrop, float, frost-heaved rock

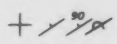
Geological boundary (defined, approximate, assumed, gradational, dip indicated) 

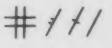
Intrusive contact with younger unit indicated 

Unconformity (defined, assumed)

Limit of geological mapping

Limit of area surveyed with aircraft 

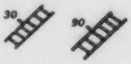
Bedding, tops known (horizontal, inclined, vertical, overturned) 

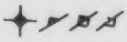
Bedding, tops unknown (horizontal, inclined, vertical, dip unknown) 

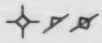
Bedding, general trend (dip unknown, top unknown; dip and top known; dip known, top unknown)

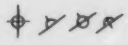
Bedding, estimated dip (gentle, moderate, steep)

Igneous flow banding (inclined, vertical)

Igneous intrusive sheets (inclined, vertical) 

Primary igneous layering, tops known (horizontal, inclined, vertical, overturned) 

Primary igneous layering, tops unknown (horizontal, inclined, vertical) 

Strike and dip of pillows, tops known (horizontal, inclined, vertical, overturned) 

Strike and dip of pillows, tops unknown (horizontal, inclined, vertical)

Primary igneous mineral lamination (inclined, vertical)

Primary igneous mineral lineation (inclined, vertical)

Flow Contact

Zone containing xenoliths

Zone of intrusive agmatite

Roof pendant (unit number indicated; too small to map separately)

Zone containing autoliths

Breccia of various origins

Slaty cleavage (horizontal, inclined, vertical, dip unknown)

Strain-slip cleavage (horizontal, inclined, vertical, dip unknown)

Schistosity, cleavage, foliation; used where ages of foliation are indicated on the map (horizontal, inclined, vertical)

- Schistosity of unknown age
- S_1
- S_2

Schistosity, gneissosity, cleavage, foliation, general trend

Gneissic foliation (horizontal, inclined, vertical, dip unknown)

Gneissic banding (horizontal, inclined, vertical)

Axial plane of minor fold (inclined, vertical, dip unknown)

Lineation (horizontal, inclined, inclined but plunge unknown, vertical)

Type of lineation denoted by letter:

- Mineral lineation — M
- S intersections — S
- Microcrenulations — C
- Boudin axes — B
- Deformed clasts — D
- Igneous inclusions — I
- Rodding, mullion structure — R
- Metamorphic aggregates — A
- Deformed pillows — P

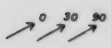
Age of lineation and of minor fold axes

Lineation of unknown age

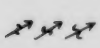
L_1

L_2

Axes of minor folds (horizontal, inclined, vertical)

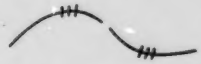


Sense of vergence of minor structures (used with minor fold axes symbol or lineation S intersection symbol; read looking along the arrow)

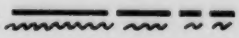


Structural trend (from aerial photographs)

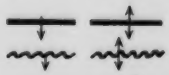
Lineament (from aerial photographs)



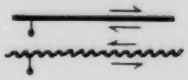
Fault (defined, approximate, assumed)



Fault (inclined, vertical)

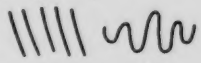


Fault (solid circle indicates downthrown side, arrows indicate relative movement)



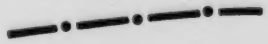
Thrust fault (teeth in direction of dip; defined, approximate, assumed) (teeth indicate upthrust side)

Zone of numerous imbricate thrust faults



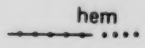
Fault zone, shear zone (width indicated)

Tectonic slide



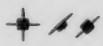
Vein fault (defined, assumed)

Mineralized bed or seam (hematite)

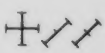


Dike, vein, or stockwork (defined, approximate, assumed; unit number and dip indicated)

Joint (horizontal, inclined, vertical)



Sheeted dikes (horizontal, inclined, vertical)



Anticline (defined, approximate, assumed)

Antiform

Syncline (defined, approximate, assumed)

Synform

Anticline and syncline (overturned)

Anticline or syncline (arrow indicates plunge)

Antiform or synform

Glacial striae (direction of ice movement known, unknown). Numbers indicate relative age, 1 being the oldest

End moraine

Minor moraines, rib moraines, washboard moraines, "annual" moraines, till ridges transverse to ice flow (irregular, straight)

Drumlins, drumlinoid ridges (direction of ice movement known, unknown)

Crag and tail hills and ramps

Glacial linear feature

Pingo or palsen

Esker (direction of flow known, unknown)

Esker (continuous, discontinuous)

Raised beaches

Limit of marine or lacustrine submergence (well marked, assumed)

Dunes

Area of sand dunes

Buried valley

Abandoned river channel, spillway, ice-marginal channels, rill patterns, etc.

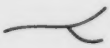
Landslide scar

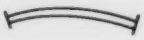
Escarpment and cirques

Fossil locality Ⓕ

Locality where age has been determined, in millions of years Ⓐ 180

Ice divide

Land system boundary 

Location of measured section 

Gravel pit or quarry (active, abandoned)

Borrow pit (active, abandoned)

Rock dump or tailings

Rock quarry (active, abandoned)

Mine (lead, zinc) Pb, Zn

Mine (lead, zine; abandoned) Pb, Zn

Mine (lead, zine; abandoned)

Mineral prospect; mineral occurrence (manganese) 9 × Mn

Placer deposit (gold) × Au

Show of oil and gas (abandoned)

Show of gas(abandoned)

Gas producer

Oil producer

Oil and gas producer

Location of drilling

Dry (abandoned)

Water source or disposal

Shearing and dip

Salt spring

Hot spring

Mineral isograd

Other alternatives when more than one

Shaft, raise, winze

Shaft (abandoned)

Trench

Open cut; axial

Adit or tunnel

Adit or tunnel (caved)

Borehole

Diamond drill hole

(Surface projection of geology inferred)

Sinkhole

Gossan

Trace of coal seam

CAMBRIAN-MIDDLE ORDOVICIAN STRATIGRAPHY OF SALMON RIVER REGION, SOUTHWEST HARE BAY, GREAT NORTHERN PENINSULA

by

Svend Stouge

INTRODUCTION

The map area is located in the southern part of Hare Bay on the Great Northern Peninsula (Figure 1). Most of the east half of the Salmon River (12P/1) area, the northeast corner of the adjacent St. Julien's (2M/4) area, and the Brent Islands of the St. Anthony (2M/5) area were mapped on a 1:50,000 scale during the 1980 field season (Figure 1). This work is a continuation of the Daniel's Harbour Project started in 1976 (Knight, 1976, 1977a, 1978, 1980; Snow and Knight, 1979; Knight and Saltman, 1980). The rocks of the area are part of the western platform carbonate and flysch sequence deposits that overlies Grenville basement rocks of the Great Northern Peninsula inlier in, western Newfoundland (see Stevens, 1970; Williams, 1975). The platformal rocks are divided into two broad groups: (a) Cambro-Ordovician sediments of platformal to basinal aspect; this sequence includes both clastic and carbonate rocks and a flysch unit at the top; (b) allochthonous sedimentary, volcanic and plutonic rocks of the Hare Bay Allochthon (Gillis, 1966; Smyth, 1971, 1973) that is thrust over the Middle Ordovician flysch unit of the Goose Tickle Formation.

Access to the area west and southeast of Salmon River is provided by woods roads which branch off the gravel highways leading to Main Brook and Croque. The coastal exposures were completed by boat.

A veneer of locally derived glacial till or the products of *in situ* weathering, highly variable in thickness, covers most of the inland area. The topographically high areas are extensively covered by spruce forest and plateaus are covered by bog. Bedrock exposure is generally poor.

Karstification has greatly modified the topography. Many dry canyons, underground waterfalls and caves are present so the drainage system in the area is unpredictable; *e.g.* rivers flow into but not out of many ponds. During early spring, the water level of the ponds is high because the underground holes are frozen, but during the summer ponds become dry as subterranean runoff is permitted. Subterranean flows resurface in many shoreline springs.

PREVIOUS WORK

The Cambro-Ordovician geology of the area was relatively unknown, with previous investigations concentrating mainly on the stratigraphy of the transported rocks north and east of the present map area (Murray, 1881; Cooper, 1937; Gillis, 1966; Tuke, 1968; Smyth, 1971; 1973; Williams, 1975; and Bostock *et al.*, 1976). The only reconnaissance account of the lower Paleozoic rocks of Hare Bay (Cooper, 1937 and Bostock *et al.*, 1976), was based on mapping in southern Hare Bay and northeast of the map area. Stevens and James (1976) presented a detailed study of the Ordovician sponge mounds of the Brent Islands. Conodont (Fahraeus, 1970; Stouge, 1980b) and graptolite age data (Erdtmann, 1971a, b) are available for the map area and surrounding areas.

STRATIGRAPHY

Present mapping revealed a sequence of carbonate rocks ranging in age from

LEGEND

AUTOCHTHON

MIDDLE ORDOVICIAN

5a **Melange:** Black and bright green shales with blocks of green chert, hemipelagic limestone, pelagic dolostone, pillow lava and massive and coarse sandstone. Siltstones at the top.

5 **Goose Tickle Formation:** Gray-green siltstone and shale; minor brown weathering sandstone and conglomerates at the top; black shales with limestone nodules/beds.

4 **Table Head Formation:** Massive bedded, micrite, biomicrite; nodular bedded, micrite-biosparite and hemipelagic limestone. Shaly at the top.

LOWER-MIDDLE ORDOVICIAN

WEST

3d **Unnamed unit:** Dolostone, finely laminated, dolomitic micrite and minor bioturbated micrite and massive bedded fenestral micrite. Stromatolites and chert at base.

3c **Catoche Formation:** Medium bedded micrite-biosparites, bioturbated, dolomitic burrows. Minor mounds and minor finely laminated dolostone.

3b **Boat Harbour Formation:** Dolostone interbedded with finely laminated dolomitic micrite and bioturbated micrite. Chert mounds; minor massive bedded micrite.

3a **Watts Bight Formation:** Vuggy, dolostone, brown. Mounds and bioturbated dolostone. Chert.

EAST

3 **St. George Group:** Stromatolite and sponge mounds predominate: chert abundant. Bioturbated micrite, medium - bedded; minor dolostone units. Undivided equivalents of 3a-d.

CAMBRIAN

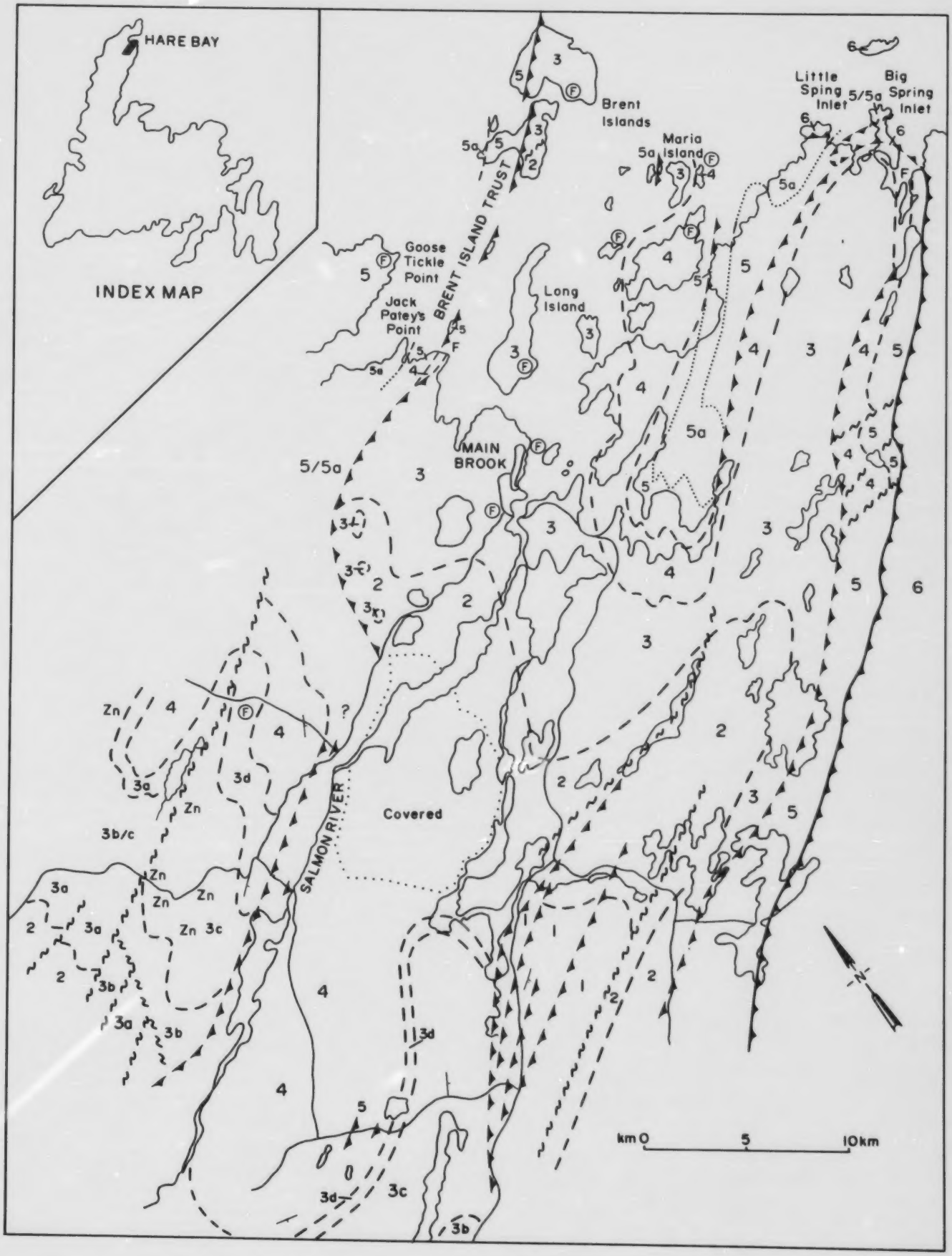
2 Massive bedded dolostone, gray, homogeneous, yellow weathering. Dark gray, brown dolostone, chert, stromatolitic mounds. Minor shale, finely laminated dolostone and vuggy dolostone.

1 Gray, rusty brown weathering shale; ribbon limestone; oolitic/oncolitic limestone; minor stromatolite mounds.

LOWER? CAMBRIAN (or older)

HARE BAY ALLOCHTHON

6 **Maiden Point Group:** Coarse and massive bedded gray sandstones, minor shale and siltstone. Minor volcanoclastic rocks.


HARE BAY
INDEX MAP
Brent Islands
Maria Island
Little Sping Inlet
Big Spring Inlet
5/5a
Goose Tickle Point
Jack Patey's Point
BRENT ISLAND TRUST
Long Island
MAIN BROOK
5/5a
SALMON RIVER
Covered
km 0 5 10km

Early Cambrian(?) to at least Middle Ordovician. The sequence breaks down into two distinct divisions, (1) shelf carbonates in the southwestern area and (2) shelf-edge carbonates, including oolitic shoals and stromatolitic mounds that pass into shelf-slope, basin shales, ribbon limestones and turbidites in the northeast.

Besides the northeast-southwest facies change, there is an northeast-southwest change in dolomitization and in the presence of the associated mineralization in the Ordovician rocks. The Ordovician shelf carbonates to the northwest are almost identical in facies, degree of dolomitization and style of mineralization to those described by Knight (1978; 1980) for the St. Barbe area. However, the Ordovician shelf edge sediments of northeastern Hare Bay are different from those in the west in that secondary dolomitization is mainly restricted to minor beds or burrows in bedded limestone and mound structures. Mineralization is absent in the northeastern part of the map area. A similar change is noted in the Canada Bay area (Knight and Saltman, 1980).

Six rock units were identified in the map area (Table 1), none of which are formalized. The Cambrian sediments comprise Units 1 and 2. The Ordovician strata are included in Units 3 (St. George Group), 4 (Table Head Formation), 5 (Goose Tickle Formation) and 5a (melange) (Figure 1). West of the Salmon River thrust, the St. George Group sediments were subdivided into Units 3a to 3d. Northeast of Salmon River, the subdivision of Unit 3 cannot be applied at present because of differences in facies and dolomitization. A new unit (3d) divisible into two subunits or members, has been recognized in the Hare Bay area. It forms the top formation of the St. George Group.

The Middle Ordovician Table Head Formation of shelf and slope deposits is divided into two members. The Middle Ordovician clastic deposits of the Goose Tickle Formation may be divisible into three members and a melange unit of Middle Ordovician age consists of two members.

A general stratigraphic scheme for the map area and approximate correlations with the Roddickton map area to the south (Knight and Saltman, 1980) and with the west coast of the Great Northern Peninsula (Knight, 1978; Knight and Snow, 1979; Schuchert and Dunbar, 1934) is presented in Table 1. Names used by Cooper (1937) are also included for reference.

CAMBRIAN

Cambrian strata in the area include the lower and middle Cambrian Unit 1 and a middle(?) to upper Cambrian carbonate sequence (Unit 2). The typical Western Platform Cambrian stratigraphy is not fully preserved here because the Labrador Group has not been recognized in the area and the lower part of the overlying Micrite Unit of Knight (1978) is apparently missing. This may be due to thrusting of lower and middle Cambrian sediments (Unit 1) over the middle(?) to upper Cambrian (Unit 2).

LOWER AND MIDDLE CAMBRIAN

Cambrian Shale-Limestone Unit (Unit 1)

In Hare Bay, lower and middle Cambrian sediments (Unit 1) are preserved in thrust slices that are exposed along the Main Brook road (Figure 1). The sediments are composed of clastic and carbonate rocks. Three stratigraphic successions (A, B and C) are preserved in separate thrust sheets from west to east. Faults and isoclinal folds have produced repetitions of the strata as well as complicating the internal stratigraphy. The three successions in combination are, however, considered to form a diverse section, which is included in a common stratigraphic interval and generally coarsens upwards.

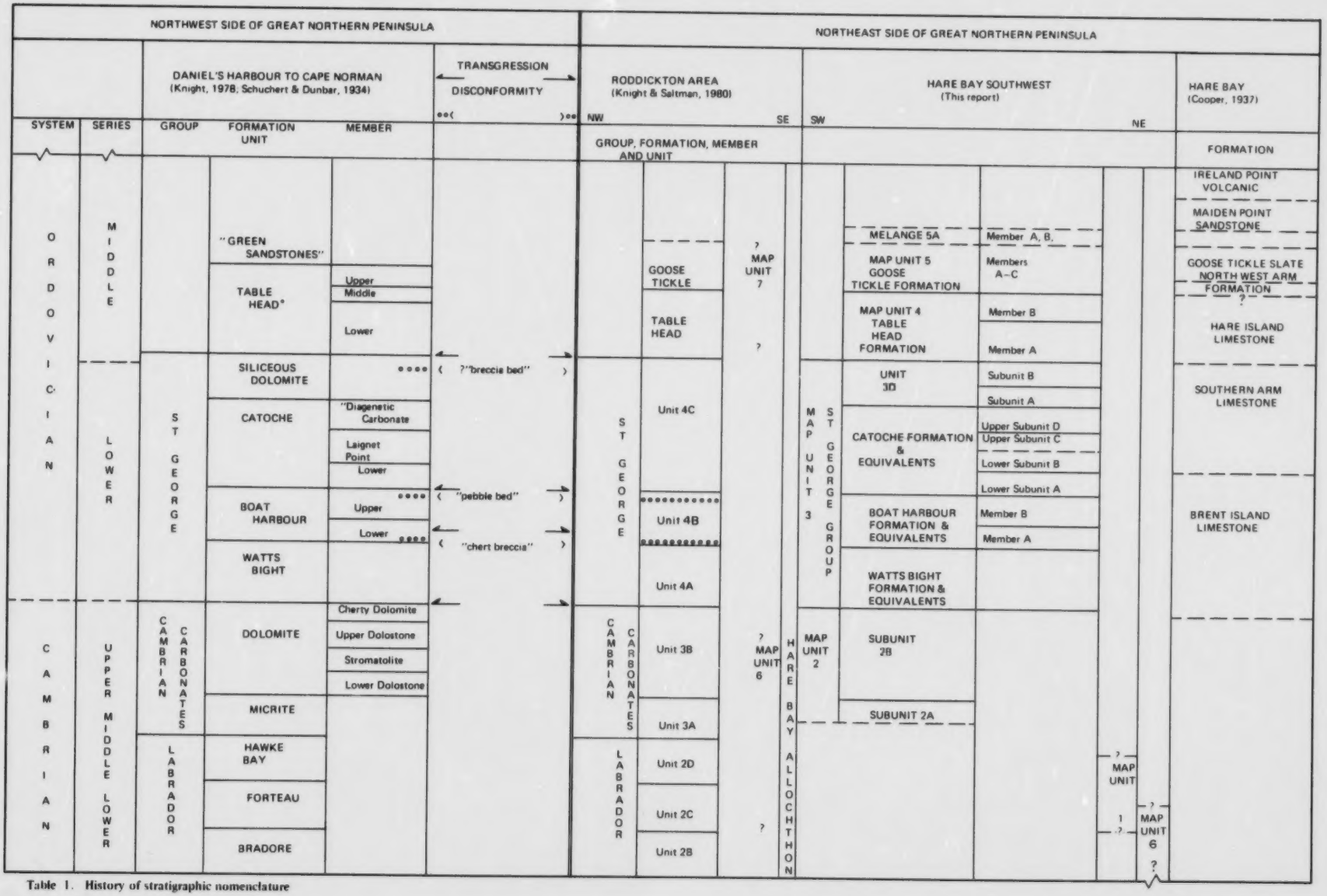


Table 1. History of stratigraphic nomenclature

A) Shale-Ribbon Limestone-Oolitic Limestone: The lower part in the westernmost thrust sheet consists of gray to green, rusty brown weathering calcareous shale with beds of siltstone, and rarely fine grained sandstone. This lithology cannot be distinguished easily from part of the Goose Tickle Formation (Unit 5, member B) of early Middle Ordovician age (see Bostock *et al.*, 1976).

The middle part consists of dark, bluish gray micrite, interbedded with rusty brown weathering gray shales. The overlying upper sediments consist of a number of limestone lithologies. These include red weathering, bedded, bluish gray micrite with yellow argillaceous stringers, and oolitic limestone with minor oncolitic limestone. The top of the upper part consists of large algal mounds associated with oolitic and oncolitic limestone. The thickness of this upper division exceeds 20 m.

(B) Oolitic Limestone - Thinly bedded Limestone Silty Limestone: The thrust slice contains a dark gray to bluish gray, massive oolitic micrite at its base which is succeeded by sandy, intraclastic, light gray and mottled limestone. Silty, finely laminated, dolomitic limestone is a minor component. Crossbeds in the oolitic micrite and ripples with oolite-filled troughs are common in the siltstone.

(C) Shale Silty Limestone Oolitic Limestone: This slice contains rusty brown weathering shale overlain by silty, homogeneous, locally sparry, micrite and uniform, massively bedded, dark gray, oolitic limestone. White quartz and black chert occur with the oolitic limestone.

MIDDLE(?) TO UPPER CAMBRIAN

Unit 2

Yellow weathering and brown weathering, massive to medium bedded, dark gray dolostones (Unit 2) form the oldest shelf sediments of the area. The sediments are well exposed in the westernmost extremity of the map area and are in continuity with units mapped further west (Knight, 1980). The unit also occupies an east-west trending belt in the center of the map area. The unit is divisible into two lithological subunits.

Subunit 2A: Massively bedded, dark gray to light gray, mottled dolostones, bioturbated dolostones with vugs partly filled by white quartz, and dull brown weathering dolostones with white stringers characterize subunit 2A. It is at least 30 m thick. This subunit correlates with the lower part of Knights Unit 3 in Canada Bay (Knight, *personal communication*, 1980; Knight and Saltman, 1980).

Subunit 2B: This subunit consists of an alternation of brown weathering, massively bedded and finely laminated, dark gray dolostone; pale yellow weathering, massive bedded, light gray, homogeneous dolostone; and medium bedded, gray rusty brown weathering, platy, commonly mudcracked dolostone. Gray dolomitic shales are minor associates. The subunit is over 300 m thick.

The succession consists of a lower part of dolostone and dolomitic shales, with stromatolitic algal mounds and dolostones. These are overlain by an upper part consisting of homogeneous dolostone which is followed by repetitive strata of dolostone. Lamellar and columnar stromatolites and cherty algal mounds are common in this upper part. This description suggests a comparison with Unit 3B (Knight, 1980) of the Canada Bay area.

ORDOVICIAN

Ordovician strata consist of the Lower-Middle Ordovician St. George Group and the Middle Ordovician Table Head and Goose Tickle Formations. The sequence is

structurally dissected by normal and thrust faults, but the partial sections overlap, and a complete stratigraphic section can be established.

Lower-Middle Ordovician

St. George Group (Unit 3)

The base of the St. George Group is marked by the top Cambrian carbonate dolostone sequence. The boundary is conformable in the area as it is elsewhere on the Great Northern Peninsula (Knight, 1980).

Cooper (1937) divided the Ordovician carbonates of Hare Bay into three formations in ascending order, the Brent Island Limestone, Southern Arm Limestone and Hare Bay Limestone. Although this division appears useful for the east to northeastern part of the map area it cannot be applied southwestwards until the type sections are defined. Thus, the stratigraphy and redefinition of the formations must await completion of mapping in the Hare Bay area.

Knight (1978) subdivided the St. George Group carbonates from the western part of the Great Northern Peninsula into four formations or units, namely, the Watts Bight Formation, the Boat Harbour Formation, the Catoche Formation (Kluyver, 1975), and the "Siliceous Dolomite" unit. Broadly, the Watts Bight Formation, the Boat Harbour Formation and the lower part of the Catoche Formation (Table 1) are equivalent to the Brent Island Limestone (Cooper, 1937). The upper part of the Catoche Formation correlates with the Southern Arm Limestone. The "Siliceous Dolomite" unit is contained in the Hare Island Limestone (Cooper, 1937; Table 1).

The rocks exposed west to southwest of the Salmon River thrust correlate with the stratigraphy of the western part of the Great Northern Peninsula (Knight, 1978, in press) and will be briefly discussed here. East to northeast of the Salmon River thrust, sediments with similar stratigraphic and structural positions to those in the west differ in dolomitization and predominance of bioturbated limy mudstone and large stromatolite mounds, but are similar to the succession described for Canada Bay (Knight and Saltman, 1980) on strike to the south. Both the west and east successions are conformably overlain by the Table Head Formation (Middle Ordovician).

Watts Bight Formation (and equivalents) (Unit 3a).

The Watts Bight Formation (Lower Ordovician) was defined by Knight (1978), who measured and described sections from the Watts Bight area. The formation is about 100 m thick in the type area and conformably overlies the Cambrian carbonate sediments. In Hare Bay, the Watts Bight Formation conformably overlies the Cambrian Carbonates. West of Salmon River, the formation comprises a succession of buff to gray, vuggy dolostone. The dolostones are characterized by bioturbation and spherical, domal and columnar algal structures. Pale blue and white cherts are common associates.

To the east of the Salmon River, the stratigraphically similar strata consist of large stromatolitic, chert-bearing mounds. The mounds have diameters up to 5 m across and chert is multicolored orange and black. This part of the St. George Group is well exposed from the northern tip of Long Island towards the south. On the southern island of the Burnt Islands the lower boundary is obscured due to folding and faulting.

Some of the mounds are similar to the sponge mounds of the Catoche Formation, and distinction between the two formations is difficult without fossil control.

Boat Harbour Formation (and equivalents) (Unit 3b)

The Boat Harbour Formation (Knight, 1978) consists of limestone and stromatolitic dolostones that overlie dolostones of the Watts Bight Formation. The Boat Harbour Formation is approximately 100 m thick at the type section.

In Hare Bay, the Boat Harbour Formation apparently overlies the Watts Bight Formation with a disconformity. The base is a sandy pebble bed with clasts of dolostones and black and pale blue chert which is well exposed on the north coast of the southern island of the Brent Islands. Sparry dolomite partly fills vugs in the bed.

A similar breccia bed was described at a similar stratigraphic position from west of Vee Pond (Knight, 1977), Boat Head, and in the Roddickton area (Knight, 1977, 1980; Knight and Saltman, 1980). Knight (1980) suggested that the bed could be a disconformity or, alternatively, a stratabound collapse breccia. The widespread distribution of this horizon favors the former interpretation. Current fossil research will focus on this problem.

The Boat Harbour Formation in the Hare Bay region consists of dark and light gray, bioturbated limestones interbedded with laminated dolostones and homogeneous dolostones. Stromatolitic domal structures associated with black chert and mudcracked, finely laminated, silty dolostones are characteristic. Two members are present in this formation.

Lower Member A: The lower member lies above the basal sand and pebble bed, and consists of a cyclic series of light gray, massively bedded micrite, domal algal mounds capped by black chert, finely laminated dolostones and minor chert bands. Massively bedded, pale gray to white and pale yellow dolostone with cherty algal structures are common in the lower part of the member.

Upper Member B: This member consists of interbeds of medium bedded, bioturbated micrite with dolomitic burrows, dolostones with argillaceous stringers, and finely laminated dolostones. Chert mounds capped by finely laminated silty dolostones, which are mudcracked, are present in minor amounts. The limestones are characterized by burrows along bedding planes. Gastropods are the main faunal component.

Catoche Formation (and equivalents) (Unit 3c)

The Catoche Formation (Kluyver, 1975; Knight, in press) consists of bioturbated, bedded limestone and mounds. On the west side of the Great Northern Peninsula, the top of the limestone is extensively dolomitized (Knight, 1978; in press). The Catoche Formation is about 300 m thick in the type area.

In Hare Bay, east of the Salmon River thrust, the Catoche Formation is not secondarily replaced by dolomite and the formation can be divided into four alternating dark-light-dark-light subunits. The Catoche Formation is approximately 185 m thick in Hare Bay.

Lower Dark Limestone subunit A (75 m): This subunit conformably overlies the Boat Harbour Formation. The limestones are gray to dark gray, medium bedded, bioturbated micrites separated by thin silty layers. Some stromatolite mounds occur. Fossils are present, but not abundant. Trilobites, brachiopods, cephalopods and gastropods are the most common taxa. Conodonts from much of the section include the species *Oepikodus communis* (Ethington and Clark) and imply a correlation with lower Catoche beds of the Catoche Formation on the west side of the Great Northern Peninsula (Stouge, in press).

Lower Light Mottled Mound subunit B (55 m): This subunit includes large mounds surrounded by micritic limestones locally rich in sparite beds and minor dolostone beds. The texture of the

mounds is the result of replacement by dolomite, giving a bioturbated limy mud. Partial dolomitization of the mound structure gives white to light gray, mottled appearances in a dark gray matrix. The mounds, which are up to 3-4 m across and 2 m high, were possibly built by sponges (Stevens and James, 1976). Commonly, the mound beds are interbedded with white, massively bedded, brittle and hard dolostones and associated with trilobites, brachiopods and straight cephalopods.

Upper Dark Gray Limestone subunit C (25 m): Upper subunit C comprises 25 m of dark gray, medium bedded and bioturbated micrites and minor black chert. Silt and shale drapes are common in micrites. Small chert mounds and chert beds are also associated.

The micrites contain a sparce fauna of cephalopods and trilobites. The latter group is represented by *Petigurus nero* Billings and *Uromystrum* cf. *affine* (Poulsen) (D. Boyce, personal communication, 1980), which indicates a late Canadian age for the strata (Boyce, 1978, 1979; Fortey, 1979). Large cephalopods cover whole bedding planes in the upper part of the subunit.

Upper Light Gray Mound subunit D (40 m): The top subunit consists of dolostone, bioturbated micrite, dolomitic stromatolitic mounds and sponge mounds. The sponges may be up to 7 m across and 3-5 m high. Chert forms a minor but characteristic constituent in this unit. In the upper part of the subunit, dolostones become increasingly common. The very top of the subunit is formed of white to pale yellow, sandy, coquina beds and domal algal mounds. Stevens and James (1976) described the sponge mounds from this unit.

Dolomitic sandy dikelike bodies were described by Cooper (1937) as cross-cutting the unit on Maria Island. He interpreted them as fissure fillings formed beneath the Table Head disconformity which had been recorded from the west side of the Great Northern Peninsula by Schuchert and Dunbar (1934). The dolomitic sandy "dikes", which are 20 cm across, resemble similar structures described from the Catoche Formation type section in mound beds by Knight (1977b). Here they are interpreted to have formed either by infilling between the mounds or by selective dolomitization of the mound structure.

Unit 3d

This lithostratigraphical unit of formational rank is 75 m thick at the type section in Little Spring Inlet and Big Spring Inlet. It consists of dolostones and interbedded dolostones and dolomitic limestones and minor bioturbated micrite. The unit conformably overlies the top member of the Catoche Formation and is gradually succeeded by the lower Table Head limestone. The unit, at present unnamed, is included in the top of the St. George Group. The unit is well exposed on Burnt Island in Pistolet Bay and on Hare Island outside the map area, where it was previously included in the Hare Island limestone (Cooper, 1937). Cooper (1937) correlated the Hare Island limestone with the Table Head Formation from the west side of the Great Northern Peninsula (Schuchert and Dunbar, 1934). Elsewhere on the Great Northern Peninsula, strata that occupy a similar stratigraphic position were referred to as the Siliceous Dolomite formation by Knight (1978) or upper dolomite formation (Klappa *et al.*, 1980).

Conodonts (Stouge, unpublished) recorded from the upper part of the unit indicate an early Whiterockian age.

This unit is divisible into two subunits.

Lower subunit A (25 m): The basal subunit is a light gray to pale yellow or white, massive dolostone which is faintly laminated. Stylolites and vertical fracturing are characteristic

but there is no macrofauna. Minor cream colored micrite with yellow argillaceous stringers occurs in thin platy beds and, locally, chert may be abundant.

The lower subunit A is only preserved within shear zones and secondary crystallization has seriously affected the sediments. Locally, the subunit has the appearance of massive "marble" (e.g. Big Spring Inlet and Maria Island east).

Upper subunit B (50 m): The lower part of this subunit consists of cyclic, repetitive, massive dolostone, finely laminated and stromatolitic dolostone, and dolomitic micrite with argillaceous stringers. Above lies a medium bedded, light to medium gray, bioturbated micrite, finely laminated dolomitic micrite and burrowed dolomitic micrite in a dolomitic and argillaceous matrix. Mudcracks are common within the finely laminated sediments and chert may be abundant locally. Fauna is not abundant and is dominated by highspired gastropods (*Hormotoma* sp.) and fragments of conodonts of Whiterockian affinity (Stouge, unpublished). This suggests that, although the unit is included in the lower Ordovician St. George Group on lithological grounds, much of it is of Middle Ordovician age.

In the western half of the map area, a light gray, massively bedded, bird's eye micrite (dismicrite) with stylolites occupies a similar stratigraphic position to subunit B.

Middle Ordovician

Table Head Formation (Map Unit 4)

The name, Table Head Formation, was given by Schuchert and Dunbar (1934) and Whittington and Kindle (1963) to the limestones, limestones and shales, and black shales that overlie dolostones of the St. George Group at Bellburns, Port au Choix and in the Port au Port area on the west side of the Great Northern Peninsula. The Table Head Formation is approximately 350 m thick at the type section (now Table Point) (Whittington and Kindle, 1963; Klappa *et al.*, 1980; Stouge, 1980b). In Hare Bay, strata of this age (Middle Ordovician) were originally referred to as the Hare Bay Limestone (Cooper, 1937). Recently, Klappa *et al.* (1980) redefined the formation to include carbonate breccias of the Table Point and Port au Port areas and included it in the Table Head Group. Their subdivisions are not recognized in the Hare Bay area or are, in general, too detailed to be used in 1:50,000 scale mapping. Consequently, the name Table Head Formation is retained for the limestones.

The Table Head Formation in the Hare Bay region is 115 to 140 m thick, and comprises gray to bluish gray micrites, biomicrites, massive to nodular bedded micrites, hemipelagic limestones and allodapic limestones with shale interbeds. The Table Head Formation is herein divided into two members that broadly correlate with the lower and middle Table Head from Table Point (Stouge, 1980b).

Lower Member A (115 m): The base of this member consists of 25 m of massively bedded and bioturbated, bluish gray micrite interbedded with minor finely laminated, dolomitic micrite and micrite with argillaceous stringers. The lower part becomes increasingly dolomitic at some localities and grades down into the top unit of the St. George Group. The bioturbated micrite often has gastropods (*Maclurites* sp.) and straight cephalopods.

The succeeding upper 90 m consists of micrite and black chert with biosparite lenses. The chert occurs as irregularly shaped stratabound bodies (?sponges) or as competent beds. The top sequence is massively bedded.

This unit has yielded trilobites and conodonts (Stouge, 1980b) of Whiterockian age (Middle Ordovician).

Upper Member B (15-40 m): The upper part of the lower member is shaly and nodular bedded in places and grades into a sequence of shaly limestone and shale of Member B. Member B is up to 40 m thick. This upper member is commonly omitted by thrusting, but it is exposed at low tide at Little Spring Inlet, and in the beach zone 3 km northwest of Main Brook.

This upper member is rich in brachiopods, cephalopods and trilobites, the latter commonly silicified. The following trilobite species have been observed (Fortey, 1979,):

Ampyx sp
Carolinites sibiricus Chuguva
Carriskia sp. nov.
Celmus sp.
Ceratophala sp.
Nileus sp.
Oenonella sp. nov.
Raymondaspis cf. *vesperhinus* Ross
Robergiella? sp.
Shumardia cf. *exophtalmus* Ross

Conodonts (Fahraeus, 1970; Stouge, 1980b) are abundantly represented and include the following species:

Acodus combsi Bradshaw
Belodella jemtlandica Lofgren
Cordylodus? horridus Barnes & Poplawski
Histiodella sp. A
Oistodus aff. *lanceolatus* Barnes & Poplawski
Peridon cf. *aculeatus* Hadding
Polonodus? clivosus (Viira)
Polonodus sp. A sp. nov.
Walliserodus ethingtoni (Fahraeus)

The fosssils suggest a Whiterockian age (Lower Middle Ordovician).

Goose Tickle Formation (Unit 5)

The Table Head Formation is conformably overlain by clastic sediments of shale and sandstone with some lime beds named the Goose tickle Formation (Cooper, 1937; Tuke, 1968). The sandstone beds are more prominent towards the top of the sequence.

The formation was interpreted to be 1860 feet (620 m) thick (Murray, 1961) or more (Cooper, 1937), but internal structural disturbance results in repetitions by isoclinal folding and thrusting, and prohibits an accurate determination of the thickness.

Erdtmann (1971a, b) recorded graptolites from the Goose Tickle Formation at Goose Tickle Point in the northwesternmost extremity of the map area which indicate the Middle Ordovician Zone 9 of the North American graptolite succession (Berry, 1960).

Member A (15 - 20 m): The basal member consists of black shale with commonly associated irregular or regular, lenticular lime nodules, or silty, finely laminated, limestone beds. The limestone nodules are typical of the member in the eastern part of the area (*e.g.* Little Spring Inlet), whereas the sediments grade into shales above the lower hemipelagic limestones of the Table Head Formation elsewhere.

The member correlates with upper Table Head black shales at Table Point (Schuchert and Dunbar, 1934; Whittington and Kindle, 1963).

Member B: Most of the member consists of thinly interbedded, gray-green shale and siltstone. The beds are generally 2 to 4 cm thick, but some siltstone beds are up to 12 cm thick. Typical Bouma (1962) turbidite cycles are recognizable, but most of them contain the upper Bouma divisions only. The siltstone beds are cross laminated and pass upwards through a parallel-laminated siltstone and pelite division into structureless, dark gray pelite. The unit coarsens upwards and grades into member C.

Member C: Gray-green shales, siltstones and brown weathering, fine grained, gray sandstones characterize the member. Flattened pebbles of sandstones 1.5 - 4 cm in size occur in the siltstones. Turbidite cycles are recognizable and

the lower Bouma (1962) divisions are preserved. These consist of graded sandstone and parallel and cross laminated siltstone.

The Goose Tickle Formation is a distal flysch which coarsens upsection, indicating the approach towards the source rocks.

Melange (Unit 5a)

A heterogeneous and chaotic unit (Member A) and siltstones (Member B) overlies the Goose Tickle Formation.

Member A: Member A consists of thinly bedded (2 cm) black and bright green shale with abundant pyrite nodules 2 - 10 cm in size. Bedding in the shales is mostly deformed or chaotic with a heterogeneous assemblage of isolated blocks resting in the shale matrix. Ghost bedding is preserved to the east within the larger blocks, which can be boulder to house size. The blocks include massively, bedded, brown weathering sandstone and shale and, an assemblage of volcanic rocks including pillow lava and porphyritic andesite associated with hemipelagic, dolomitic limestone and chert. Blocks of pelagic, finely laminated crossbedded dolostone are also common. The latter show evidence of soft-sediment deformation. The volcanic rock assemblage occurs only in the east whereas the sedimentary blocks are ubiquitous. The source of the massive sandstone and volcanic blocks is the Maiden Point Group of the Hare Bay Allochthon (Smyth, 1973), but no source is known for the hemipelagic carbonates.

Williams (1975) included Unit 5a in the Northwest Arm Formation (see Cooper, 1937), and separated the unit as a structural slice. More mapping is required to verify this interpretation. At present, the strata within the map area differ from the Northwest Arm Formation by their chaotic appearance (melange) and heterogeneous assemblage of blocks. This is in contrast to the stratabound and monomict lime breccias of the Northwest Arm Formation at its type section. Member A is interpreted as a melange formed during the thrusting of the Hare Bay Allochthon.

Member B: This member apparently conformably overlies member A at Fack Patey's Point. It is composed of gray siltstone interbedded with 1 to 3 cm thick sandstone beds. These beds may be conglomeratic with sedimentary siltstone and sandstone clasts (1 x 3 cm).

LOWER? CAMBRIAN

Hare Bay Allochthon (Unit 6)

Allochthonous rocks for the eastern boundary of the map area and form part of the Maiden Point Formation. It consists of massively bedded (0.5 to 1.5 m beds), brown weathering graywackes, interbedded with green siltstones. The strata are coarse to medium grained. Complete Bouma (1962) turbidite cycles are preserved and sole marks are prominent. The formation is presumed to be of Lower? (or older) Cambrian age (Smyth, 1973; Williams, 1975).

South of Big Spring Inlet and inland, lithologies of white weathering, brown shale and siltstone are prominent. Their stratigraphic affinity is unknown.

DIKES

In the eastern extremity of the map area, a swarm of young diabase (?) dikes averaging 1 m in thickness cut the Ordovician strata. The dikes trend northeastwards and are only affected by small scale faults. The dikes, therefore, are younger than the major deformation of the strata in Hare Bay.

PLEISTOCENE

Pleistocene marine sediments are exposed in many places up to 20 m above present sea level in the lower parts of valleys in the map area. They consist of bluish gray to pale red silts and

claystones with rounded pebbles 1 - 5 cm in size. The sediments are very fossiliferous and contain a diverse fauna which includes:

Arthropods:	*Balanus hameri* (Ascanius) (a barnacle)
Pelecypods:	*Astarte mortagni striata* (Leach)
	Mya truncata Linne
Gastropods:	*Buccinum tenue* Gray
	Buccinum cyaneum Bruguiere
	Natica sp.
Brachiopods:	*Hemithiris psittacea* (Emelin)
Bryozoans:	(fragments)
Microfossils:	Ostracods and, in particular, foraminifera.

STRUCTURE

The rocks of the area were affected by at least two deformations (Smyth, 1973). The first deformation (D_1) folded the strata into a series of anticlines and synclines which commonly are either overturned or recumbent; the folds trend northeastwards and plunge at moderate angles in northeasterly or southwesterly directions. Associated with the folding is a penetrative cleavage which, except in the fold hinges, is subparallel to bedding. Structural pinching out of incompetent units is common, and isoclinal folding is developed in shale units (*e.g.* Units 1 and 5).

Two, perhaps three, thrust faults associated with the first deformation (D_1) are recognized within the autochthonous sequence. These are: (1) the Salmon River thrust, which juxtaposes St. George Group strata against Table Head/Goose Tickle Formations; (2) the Burnt Island thrust, which juxtaposes the southern Cambrian carbonates over ?Goose Tickle Formation or Table Head Formation, whereas in the north on Brent Islands, St. George Group strata override the Goose Tickle Formation; and (3) the Main Brook Road thrust, which juxtaposes Cambrian carbonates and the St. George Group against the shales and oolitic limestones of Unit 1. The thrusts were probably formed during recumbent folding synchronous with emplacement of the Hare Bay Allochthon over the carbonate sequence.

The uncertain age affinity of the shale unit exposed west of Main Brook (Figure 1) means that the southern extension of the Brent Island thrust could either join with the Salmon River thrust or extend across the map area to connect with the Main Brook road thrust fault.

A second deformation (D_2) is developed in the rocks of Units 1 to 5. This deformation folded the penetrative cleavage of D_1 into open synclines and anticlines.

Minor northeast and northwest trending faults cut the strata. In the carbonate terrain, these are commonly associated with "pseudobreccias" in the limestones or with prominent breccias within dolostone units.

ECONOMIC GEOLOGY

Zinc mineralization is located to the southwest and to the west of the area (Cant, 1976; Cant and van Ingen, 1976; Knight, 1980) and east of the Salmon River thrust. The mineralization is associated with white sparry dolomite which has replaced limestone ("pseudobreccia") of the Catoche Formation. The zinc occurrences are exposed mainly near northeast trending faults and are located sporadically for distances of 14 km near the faults. Minor zinc occurrences have also been observed in limestones unaffected by secondary dolomitization. No new significant zinc mineralization was found.

The potential for hydrocarbons within the area lies in the shales of the Goose Tickle Formation and Unit 5a. These pyritiferous and bituminous black

shales are tentatively suggested as source rocks. Vuggy carbonate rocks within the Watts Bight Formation and "Diagenetic Carbonates" are potential reservoirs. The northeast trending faults and the recumbent folds are potential traps.

The Pleistocene marine sequence is, in places, completely free of coarser particles and is a clean clay. This may be of potential use in the ceramic industry.

Commercial limestone deposits in Hare Bay have been described by Cooper (1937), Harris (1962) and DeGrace (1974).

ACKNOWLEDGEMENTS

Keith Bessey of Main Brook, and Dan Crummel of St. John's provided assistance during the field season. I. Knight, B. Kean, S.P. Colman-Sadd, J. Hibbard, and R. Smyth Department of Mines and Energy, Mineral Development Division, St. John's, read the manuscript.

REFERENCES

Berry, W.B.N.
1960: Graptolite faunas of the Marathon Region, West Texas. University of Texas, Publication 6005, 179 pages.

Bostock, H.H., Cumming, L.M., Williams, H. and Smyth, W.R.
1976: Geological map of the Strait of Belle Isle region. Geological Survey of Canada, Open File 347.

Bouma, A.H.
1962: Sedimentology of some flysch deposits. Elsevier Publishing Company, Amsterdam, 168 pages.

Boyce, W.D.
1978: Recent developments in western Newfoundland Cambro-Ordovician trilobite biostratigraphy. *In* Report of Activities for 1977. *Edited by* R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 78-1, pages 80-84.

1979: Further developments in western Newfoundland Cambro-Ordovician biostratigraphy. *In* Report of Activities for 1978. *Edited by* R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 79-1, pages 7-10.

Cant, J.W.
1975: Commodore Project. A geochemical and geological survey of zinc bearing carbonate rocks in the Main Brook area, Great Northern Peninsula, Newfoundland. Shell Canada Resources Limited. Unpublished Report, 25 pages.

1976: The Commodore Project, Great Northern Peninsula, Newfoundland. Shell Canada Resources Limited, Unpublished progress report, 21 pages.

Cant, J.W. and Van Ingen, R.
1976: The Commodore Project, Great Northern Peninsula, Newfoundland. Shell Canada Resources Limited, Unpublished progress report, 31 pages.

Cooper, F.R.
1937: Geology and mineral deposits of the Hare Bay area. Geological Survey of Newfoundland, Bulletin 9, 36 pages.

DeGrace, J.R.
1974: Limestone resources of Newfoundland and Labrador. Department of Mines and Energy, Mineral Development Division, Report 74-2, 117 pages.

Erdtmann, B.D.
1971a: Ordovician graptolite zones of Western Newfoundland in relation to paleogeography of the North Atlantic. Geological Society of America Bulletin volume 82, pages 1509-1528.

1971b: *Tetragraptus otagoensis* and *fanograptus terranovensis*, n.sp. Ordovician graptolites from western and northern Newfoundland. Journal of Paleontology, volume 45, pages 258-264.

Ethington, R.L. and Clark, D.L.
1971: Lower Ordovician conodonts in North America: Geological Society of America, Memoir 127, pages 63-82.

Flower, R.A.
1978: St. George and Table Head cephalopod zonation in western Newfoundland. Geological Survey of Canada, Paper 78-1A: Current Research, Part A, pages 217-224.

Fortey, R.A.
1979: Early Ordovician trilobites from the Catoche Formation (St. George Group), western Newfoundland. Geological Survey of Canada, Bulletin 321, pages 61-114.

Fahraeus, L.E.
1970: Conodont-based correlations of Lower and Middle Ordovician strata in western Newfoundland. Geological Society of America Bulletin, volume 81, pages 2061-2076.

Gillis, F.W.
1966: Great Northern Peninsula (parts of 12I, P; and of 2L, M). *In* Report of Activities, May to October, 1965. Geological Survey of Canada, Paper 66-1. *Edited by* S.E. Jenness, pages 178-181.

Harris, I. McK.
1962: Report of 1962 brick shale - limestone survey; Newfoundland Department of Mineral Development Division. Unpublished report, 81 pages.

Klappa, C.F., Opalinski, P.R. and James, N.P.
1980: Middle Ordovician Table Head Group of western Newfoundland: a revised stratigraphy. Canadian Journal of Earth Sciences, Volume 17, pages 1007-1019.

Kluyver, H.M.
1975: Stratigraphy of the Ordovician St. George Group in the Port au Choix area, western Newfoundland. Canadian Journal of Earth Sciences, Volume 12, pages 589-594.

Knight, I.
(in press): Cambro-Ordovician carbonate stratigraphy of western Newfoundland; sedimentation, diagenesis and zinc-lead mineralization. Manuscript.

1977a: The Cambro-Ordovician platformal rocks of the Northern Peninsula. *In* Report of Activities for 1976. *Edited by* R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Divison, Report 77-1, pages 27-34.

1977b: Cambro-Ordovician platformal rocks of the Northern Peninsula, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 77-6, 27 pages.

1978: Platformal sediments on the Great Northern Peninsula: Stratigraphic studies and geological mapping of the north St. Barbe District. *In* Report of Activities for 1977. *Edited by* R.V. Gibbbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 78-1, pages 140-150.

1980: Geological mapping of parts of the Eddies Cove, Salmon River and adjacent map areas. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 1-9.

Knight, I. and Saltman, P.
1980: Platformal rocks and geology of the Roddickton map area, Great Northern Peninsula. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 9-28.

Murray, A. and Howley, J.P.
1881: Geological Survey of Newfoundland, 1864-1880.

Schuchert, C. and Dunbar, C.O.
1934: Stratigraphy of western Newfoundland. Geological Society of America, Memoir 1, 123 pages.

Smyth, W.R.
1971: Stratigraphy and structure of part of the Hare Bay Allochthon, Newfoundland. Geological Association of Canada, Proceedings. Volume 24, No. 1, pages 47-57.

1973: The stratigraphy and structure of the southern part of the Hare Bay allochthon, northwest Newfoundland; Unpublished Ph.D. thesis, Memorial University of Newfoundland, 172 pages.

Snow, G. and Knight, I.
1979: Geological mapping of the carbonates of the Brig Bay map area, Newfoundland. *In* Report of Activities for 1978: *Edited by* R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 79-1, pages 1-6.

Stevens, R.K.
1970: Cambro-Ordovician flysch sedimentation and tectonics in west Newfoundland and their possible bearing on a proto-Atlantic Ocean. Geological Association of Canada, Special Paper 7, pages 165-177.

Stevens, R.K. and James, N.P.
1975: Large spongelike reef mounds from the Lower Ordovician of west Newfoundland. Abstract, Annual Meeting, Geological Society of America, Denver, Colorado, page 1122.

Stouge, S.
1980a: Lower and Middle Ordovician conodonts from central Newfoundland and their correlatives in western Newfoundland. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 134-142.

1980b: Conodonts of the Table Head Formation (Middle Ordovician), western Newfoundland. Unpublished Ph.D. thesis, Memorial University of Newfoundland, St. John's, 412 pages, 18 plates.

(in press): Preliminary conodont biostratigraphy and correlation of Upper Canadian carbonates from the St. George Group, Great Northern Peninsula, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division Report.

Tuke, M.F.
1968: Autochthonous and allochthonous rocks of the Pistolet Bay area in northernmost Newfoundland. Canadian Journal of Earth Sciences, Volume 5, pages 501-513.

Whittington, H.W. and Kindle, C.M.
1963: Middle Ordovician, Table Head Formation, western Newfoundland. Geological Society of America Bulletin, volume 74, pages 745-758.

Williams, H.
1975: Structural succession, nomenclature and interpretation of transported rocks in western Newfoundland. Canadian Journal of Earth Sciences, volume 12, pages 1874-1894.

GEOLOGY OF CARBONIFEROUS STRATA IN THE DEER LAKE (12H/3) AND RAINY LAKE (12A/14) MAP AREAS, NEWFOUNDLAND

by

R.S. Hyde and M.J. Ware

INTRODUCTION

Carboniferous rocks in the Deer Lake region of western Newfoundland were deposited in an intermontane trough called the Deer Lake Basin. A thorough knowledge of the stratigraphy and structure of the basin is important because of the presence of energy-related resources such as uranium, coal, shale oil, and natural gas (Hayes, 1949; Baird, 1950; Fleming, 1970; Hyde, 1979; Hyde and Ware, 1980). This paper summarizes the results of geologic mapping of Carboniferous strata in the central and southern portions of the Deer Lake Basin (within the Deer Lake (12H/3) and Rainy Lake (12A/14) map areas). The entire basin has now been mapped at a 1:50,000 scale. Pre-Carboniferous rocks marginal to and within the basin are also briefly discussed.

Two major Carboniferous stratigraphic units are present in the area mapped, namely, the Anguille Group (Tournaisian) and the overlying Deer Lake Group (Visean-Westphalian A). Hyde (1979) subdivided the Anguille Group into six informal units, three of which occur in the area mapped in 1980. These three units were first delineated by Popper (1970). From stratigraphic bottom to top, these are: (1) a siltstone + lithic sandstone + tan carbonate unit; (2) a siltstone + lithic sandstone unit; and (3) a siltstone + lithic sandstone + arkose unit. Estimated maximum thicknesses for the three units in the map area are 1000 m, 1500 m, and 1000 m, respectively. Werner (1955), Baird (1959), and Belt (1969) have subdivided the Deer Lake Group into four formations, all of which outcrop in the map area. These are, from bottom to top: (1) the North Brook Formation; (2) the Rocky Brook Formation; (3) the Humber Falls Formation; and (4) the Howley Beds (Howley Beds may be partially equivalent to the Humber Falls Formation).

Physiographically, the Deer Lake Basin is rimmed by an upland area underlain by pre-Carboniferous rocks. Internally, the basin is marked by two up-faulted highland areas which are mainly underlain by Anguille Group rocks, called the Birchy Ridge - White Bay block and the Glide Mountain block. These structural blocks are largely surrounded by lowlands that are underlain by the Deer Lake Group.

Significant findings in 1980 are: (1) geographic extension of uranium occurrences in the Deer Lake Group; (2) discovery of bituminous rocks and minor copper mineralization in the Deer Lake Group; (3) confirmation of Popper's (1970) subdivision of the Anguille Group; (4) discovery of an area underlain by the Howley Beds on the western side of Grand Lake; and (5) subdivision of the Glide Mountain block into three smaller blocks, one of which contrasts structurally with the other two.

In addition to these findings, the contact between the North Brook and Rocky Brook Formations is redefined.

STRATIGRAPHY

ORDOVICIAN OR OLDER

Quartz-mica schist, quartzite, phyllite (Unit 1a)

These rocks occur in a fault-bounded slice and are probably part of the Fleur dy Lys Supergroup. A prominent cleavage

LEGEND

CARBONIFEROUS

DEER LAKE GROUP

11 **Howley Beds:** 11a, Red and gray pebble conglomerate, minor cobble-boulder conglomerate, gray, red, tan, and green, very fine to very coarse grained sandstone, red, gray, and green siltstone and mudstone, minor gray microcrystalline limestone, coal, ironstone; arranged in poorly defined fining upward sequences; 11b, gray and green, medium to very coarse grained sandstone and pebble conglomerate, red, gray brown, and green, very fine to fine grained sandstone and siltstone, minor gray microcrystalline limestone; arranged in well-defined fining upward sequences.

10 **Humber Falls Formation:** Gray and red, coarse to very coarse grained sandstone, red, gray, and light green pebble and granule conglomerate, red, fine to medium grained sandstone.

9 **Rocky Brook Formation:** 9a, Calcareous, red and gray siltstone, gray and green mudstone,,gray, microcrystalline and stromatolitic limestone, minor red and gray, fine to medium grained sandstone, oil shale; 9b, calcareous, gray siltstone, gray and green mudstone, gray microcrystalline, stromatolitic, and oolitic limestone, dark brown oil shale.

8 **North Brook Formation:** 8a, Mainly red, pebble to cobble conglomerate, also gray conglomerate and red, medium to very coarse grained sandstone; 8b, mainly red, brown, and reddish gray, medium to very coarse grained sandstone, minor conglomerate and siltstone; 8c, mainly gray and greddish gray, medium to very coarse grained sandstone and siltstone arranged in well-defined fining upward sequences; 8d, mainly red, very fine to medium grained sandstone and red siltstone.

ANGUILLE GROUP

7 **Coarse grained arkose unit:** Mainly very fine to medium grained, dark gray sandstone, dark gray siltstone, black mudstone, but with thick bedded, gray and pink, coarse to very coarse grained arkose and pebble conglomerate, minor gray microcrystalline limestone.

6 **Gray sandstone unit:** Very fine to fine grained, dark gray sandstone, dark gray siltstone, and black mudstone; all of above alternating with light gray, medium to very coarse grained sandstone; minor pebble conglomerate, calcareous siltstone and sandstone, gray microcrystalline limestone, limestone breccia.

5 **Tan carbonate unit:** Mainly very fine to fine grained, dark gray sandstone, dark gray siltstone, black mudstone, and light gray, medium to coarse grained sandstone, but with thin to medium bedded, tan and orange carbonate interbedded with dark gray siltstone and black mudstone.

PRE-CARBONIFEROUS (?)

4 Green and gray schistose metaconglomerate, metasandstone, green chloritic schist.

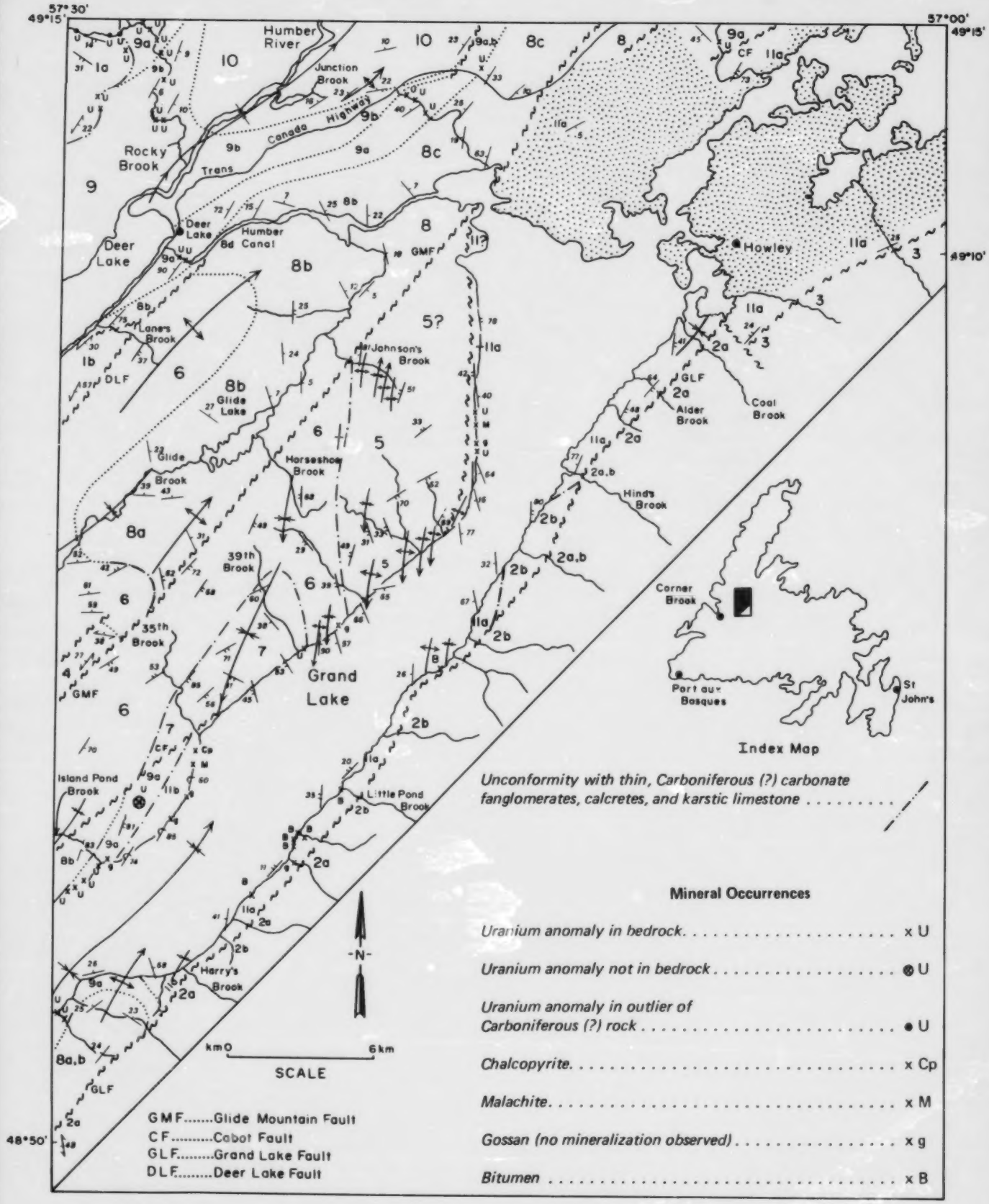
SILURIAN-DEVONIAN

3 Fine to medium grained, gray and pink, equigranular granite with minor amounts ofmuscovite and hornblende.

2 2a, Massive and pillowed, amygdaloidal, dark gray and green, mafic to intermediate volcanic rocks, some feldspar phyric varieties; 2b, red, pink, and gray felsic to intermediate volcanic rocks, mainly welded tuff, nonwelded lapilli tuff and agglomerate; minor sandstone.

ORDOVICIAN AND/OR OLDER

1 1a, Gray, buff, and black marble, minor chlorite schist; 1b, quartz-mica schist, quartzite, phyllite.


57°30'
49°15'
57°00'
49°15'
49°10'
48°50'
Humber River
Junction Brook
Canada Trans Highway
Rocky Brook
Deer Lake
Deer Lake
Humber Canal
Howley
Lane's Brook
Johnson's Brook
Glide Lake
Glide Brook
Horseshoe Brook
39th Brook
35th Brook
Grand Lake
Island Pond Brook
Little Pond Brook
Harry's Brook
Alder Brook
Coal Brook
Hind's Brook
Corner Brook
Port aux Basques
St John's
GMF
DLF
GLF
CF
Index Map
Unconformity with thin, Carboniferous (?) carbonate fanglomerates, calcretes, and karstic limestone
Mineral Occurrences
Uranium anomaly in bedrock x U
Uranium anomaly not in bedrock ⊗U
Uranium anomaly in outlier of Carboniferous (?) rock •U
Chalcopyrite x Cp
Malachite x M
Gossan (no mineralization observed) x g
Bitumen x B
N
km 0 6 km
SCALE
GMF.....Glide Mountain Fault
CF.....Cabot Fault
GLF.....Grand Lake Fault
DLF.....Deer Lake Fault

is subparallel to bedding, and consistently dips towards the east. Examination of thin sections shows that these rocks have reached biotite grade metamorphism.

Carbonate rocks (Unit 1b)

Carbonate rocks, probably Cambrian in age, are in most places thoroughly recrystallized to a gray to buff, homogeneous, fine grained marble. However, marbles with quartz clasts up to 30 cm in size and laminated marbles with thin chloritic selvages are also present. Two small areas show preservation of stromatolites and trough crossbeds.

Silurian-Devonian volcanic rocks (Unit 2)

Green and gray, mafic to intermediate volcanic rocks (2a) are characteristically massive and amygdaloidal; the amygdules are usually on the order of 1-5 mm in long dimension (1.5 cm, the largest observed). The vesicles are usually filled with calcite, but some are filled with quartz and others are unfilled. Some of the rocks contain isotropically oriented plagioclase phenocrysts up to 2 mm in length. We also noted pillowed lavas and broken pillow breccias.

Felsic to intermediate volcanic rocks (2b) adjacent to the Deer Lake Basin are red, pink, and gray. Pinhead-size quartz and flesh-colored feldspars 1 mm in length are present in some rocks as phenocrysts. Many of the rocks appear to be pyroclastic, and include welded tuffs (very abundant), nonwelded lapilli tuffs, and agglomerates. Fragments in the agglomerates reaoh up to 5 cm in size and include mafic volcanic fragments and partially collapsed pumice. A felsite dike, oriented parallel to a foliation cutting mafic volcanic rocks, occurs in the extreme southwestern part of the map area. Quartz-feldspar porphyry (intrusive?) is present as a thin strip separating granitic rocks from Carboniferous strata southeast of Howley.

Our observations of texture suggest largely subaerial volcanism. This, in turn, suggests that these volcanic rocks are correlative with Silurian-Devonian volcanic rocks that are exposed along strike to the northeast of the map area (Mic Mac Lake Group, Springdale Group; Hyde, 1979, Taylor *et al.*, 1980).

Silurian-Devonian granitic rocks (Unit 3)

Pink and gray, equigranular granitic rocks are well exposed along the brook between Howley and Coal Brook. The granitic rocks are fine to medium grained and contain muscovite and amphibole.

Pre-Carboniferous metasedimentary rocks (Unit 4)

Foliated metaconglomerates and minor metasandstones and chloritic schists were previously regarded by Popper (1970) as the basal unit of the Anguille Group. In the Corner Brook map area, west of the present map area, Hyde (1970) also assigned similar rocks to the Anguille Group. These rocks are now, however, interpreted to be pre-Carboniferous in age based on the following points: (1) they are restricted to a beltlike region as an extension of a fault-bounded strip containing pre-Carboniferous volcanic rocks to the southwest in the Corner Brook map area (Hyde, 1979, Unit 14); (2) petrographic study of rocks from Unit 14 (Corner Brook map area, Hyde, 1979) revealed the presence of metasediments interbedded with felsic volcanic rocks; (3) the metaconglomerates are more deformed than the typical sedimentary rocks of the Anguille Group; and (4) chlorite grade metamorphism in the metaconglomerates has not been seen elsewhere in the Anguille Group.

CARBONIFEROUS

Anguille Group (Units 5-7)

Within the map area, the Anguille Group (Tournaisian) outcrops in the Glide Mountain structural block. This block is geographically bounded in this area by Deer and Grand Lakes on its flanks, and the Humber Canal to the northeast. We agree with Popper's (1970) subdivision of the Anguille Group in the map area, and wish to emphasize (as did Popper) that: (1) contacts between the units are gradational and (2) thin to medium bedded, dark gray, very fine to medium grained sandstones, dark gray siltstones, and black carbonaceous mudstones are the most common lithologies in each of the three units. Rather than repeat these lithologies throughout the text, these will be termed the common facies association (CFA). Southeast of the Glide Mountain Fault, the following succession, in ascending order is recognized.

Tan carbonate unit (Unit 5)

Interbedded with siltstones and mudstones of the CFA beds are laminae and beds (range: <1 mm to 50 cm thick, average about 5 cm) of tan and orange weathering, gray carbonate rocks. These carbonates are commonly impure, and grade compositionally into calcareous siltstones. The carbonate fraction consists of micrite and microspar of a probable iron-rich carbonate mineral (Popper, 1970, stated that the carbonate is a ferroan dolomite, but we found many examples in the field that fizzed readily with cold, 10% HCl, suggesting that some of the carbonate is calcite). Layers of the carbonate show sharp but irregular boundaries with the interbedded siltstones and mudstones. Internally, the beds are laminated, cross-laminated, or massive. In some areas, the carbonate layers have been pulled apart, broken, and slumped due to soft-sediment deformation.

In the CFA, sandstones are dominantly fine grained and micaceous. Some beds are plant bearing, whereas others contain tan carbonate nodules up to 2 cm in diameter. Bedding in the CFA beds tends to be even and persistent, and bed thicknesses are usually 5-20 cm. Graded bedding is present, but uncommon. Sedimentary structures include symmetric and asymmetric, straight-crested ripples, ripple cross-lamination, climbing ripple lamination, and parallel lamination. More rarely occurring structures are sole marks such as load casts, grooves, prod marks, flute marks, and longitudinal ridges. Siltstones and mudstones in the CFA beds are micaceous, carbonaceous and, rarely, contain pyrite nodules. Pyrite nodules up to 10 cm in diameter occur on Johnson's Brook.

In addition to the carbonates and CFA beds, light gray, coarse to very coarse grained sandstones, pebbly sandstones, and conglomerates are also present. The sandstones usually occur as thick, massive beds. Trough cross-stratification occurs in places, and sets are usually greater than 10 cm thick. The conglomerates contain clasts up to 10 cm in apparent long axis. Quartz is the most common clast type; we also observed clasts of felsic and mafic volcanics, pink granite and jasper.

Paleoflow reconstructions for the tan carbonate unit showed general sediment transport in a northerly to northeasterly direction. This agrees with the results obtained by Popper (1970).

Before discussing the depositional environment of this unit, it is first noted that no marine beds have been documented for the Anguille Group in the Deer Lake Basin, and previous authors (Belt, 1969; Popper, 1970; Hyde, 1979) have regarded the Anguille Group as mainly lacustrine in origin. Accepting this interpretation, it is evident from the description above that the tan

carbonate unit was deposited in a relatively quiet-water environment in which deposition of fine sand and mud prevailed. Some of the facies in the carbonate unit (*i.e.*, CFA beds, carbonates, and coarse sandstone-conglomerate) appear to be arranged in coarsening-upward sequences, ranging from about 5-20 m thick. It is suggested that these coarsening-upward sequences are related to prograding, lacustrine deltas. Some of the coarse grained sandstones exhibit sharp, erosive basal contacts which we interpret as representing deposition in distributary channels.

Some of the finer grained beds are interpreted as turbidites based on the presence of sharp basal contacts, graded bedding, and current-induced sole marks. Popper (1970) first interpreted these beds as turbidites, but we feel that Popper (1970) overemphasized the amount of turbidity current activity. Our estimate of the percentage of turbidite beds is no more than 5% of the entire stratigraphic unit. The turbidites and associated fine grained clastic sediments are here placed in prodelta and delta-fringe subenvironments. Fine to coarse grained sandstones probably originated as nearshore sands (distributary mouth bars, bay mouth bars). Carbonate rocks are regarded as inorganic precipitates. Their occurrence and mineralogy was probably controlled by reduced clastic sedimentation and lake water chemistry.

Gray sandstone unit (Unit 6)

In this unit, the CFA beds are similar to those in the tan carbonate unit except that sole marks and graded bedding are very rare in the gray sandstone. The CFA beds, as is the case in the tan carbonate unit, are interbedded with thick beds of medium to coarse grained, light gray sandstone and minor conglomerate. These coarser grained sandstones are mostly massive, but medium-scale (greater than 10 cm in thickness) trough crossbeds are not uncommon. Conglomerates contain clasts up to 15 cm in apparent long axis. Clast rock types are dominated by vein quartz and felsic volcanics. Rarely, gray, microcrystalline limestone layers are interbedded with the CFA beds. One bed 70 cm thick contains angular carbonate fragments up to 1.5 cm in size set in a carbonate matrix.

Only a few paleocurrent measurements were made, and these were on structures which do not permit polarity to be established (parting lineation, symmetric ripples, groove marks). Generally, these measurements indicate a north-south paleoflow. Popper (1970) measured 23 crossbeds in the gray sandstone unit in the Deer Lake map area. Although we observed numerous crossbeds, none were considered to be sufficiently well exposed for accurate measurements.

Popper (1970) suggested that the gray sandstone unit was fluvial and lacustrine in origin. Hyde (1979) inferred that the coarse grained sandstones and conglomerates represented distributary channels of a lacustrine delta, and that the CFA beds were the product of associated deltaic subenvironments (*e.g.*, prodelta, interdistributary bay). This latter interpretation for the gray sandstone unit is adopted in this report. In general, the depositional environment for the gray sandstone unit is not very different from that of the tan carbonate unit, but two differences can be noted: (1) less turbidity current activity in the gray sandstone unit, and (2) much less deposition of carbonate sediment in the gray sandstone unit.

Arkose unit (Unit 7)

The third, and highest, stratigraphic unit is here termed the arkose unit. Popper (1970) named this the red arkose suite, but this overemphasizes the redness of the arkoses. In fact, the arkoses, although some of them have a pink cast, are usually gray, and lack a brick-red color.

The arkoses are thick bedded, medium to coarse grained sandstones and pebbly sandstones. Only a few medium-scale, trough crossbeds were observed. Graded beds are also rare. The arkoses commonly have sharp top and bottom contacts, and we observed scouring and channeling of arkoses into CFA beds. Quartz and feldspar grains in the arkose are quite angular. Conglomerates are also present in which clasts reach 50 cm in apparent long axis. The clasts are subrounded and consist largely of quartz, flesh-colored feldspar, and felsic volcanic debris.

The arkoses and conglomerates are interbedded with the CFA beds, which are broadly similar to those in the other units. In the arkose unit, however, the amount of cross-stratification, particularly in medium grained sandstone, is more abundant and the CFA beds lack grading and sole marks.

Very few paleocurrent measurements were obtained from this unit, but we agree with Popper (1970) that the source area was to the south and east. This is the only region which could have supplied large angular feldspars.

Popper (1970) concluded that the arkoses and conglomerates were deposited on alluvial fans. Our interpretation is different, for much more deposition of bouldery material and examples of debris flows ought to be present if the coarse sediment was deposited on normal, alluvial fans in arid climactic conditions. We suggest fluvial deposition on the subaerial portion of deltas. Graded arkose beds and a paucity of cross-stratification in arkoses are interpreted as reflecting flood deposition. The abundance of feldspar in the coarse grained sandstones also marks a change in provenance to more granitic source rocks. The CFA beds probably represent nearshore, deltaic deposition in a variety of subenvironments. Close stratigraphic association of the coarse arkoses and fine grained CFA beds in coarsening upward sequences suggests progradation followed by abandonment of deltaic lobes.

Deer Lake Group (Units 8-11)

North Brook Formation (Unit 8)

The contact between the North Brook Formation and the underlying Anguille Group is problematical, largely because of insufficient age data and nonexposure of the contact. Southwest of Glide Lake, there is almost a 90 degree difference in strike direction, which may be due to an angular unconformity. No debris from the Anguille Group was observed in the basal part of the North Brook Formation. The contact between the North Brook Formation and the overlying Rocky Brook Formation is here redefined such that the base of the Rocky Brook Formation is marked by the first appearance of gray or green siltstone or mudstone. Previously, a succession of red siltstones and red, very fine to fine grained sandstones were regarded as the basal part of the Rocky Brook Formation (Hyde, 1979), but these red strata are now placed in the upper part of the North Brook Formation.

The North Brook Formation as a whole represents a well defined, fining upward megasequence (< 1-5 km thick) which is present in all areas. Thus, we have subdivided the North Brook Formation into informal units based on the most prevalent rock type and the presence or apparent absence of medium-scale (1-5 m thick) fining upward sequences.

Unit 8a is characterized by red-matrix conglomerates interlensed with red, medium to very coarse grained sandstones. Scouring and cross-stratification accompany this interlensing. In places (*e.g.* Lane's Brook), sandstones and the matrix of conglomerates are gray. Clasts in the conglomerate are mostly pebbles, but apparent long axes up to 45 cm are present. Clast rock types vary with geographic position, and are governed largely by those rock types in adjoining pre-Carboniferous terrains and to a lesser extent by size. For example, the predominant clast rock types in North

Brook Formation conglomerates along Lane's Brook are quartz (mostly present in fine pebbles), quartz-mica schist, and phyllite. In contrast, southwest of Harry's Brook, most clasts are granitic types, feldspars, and pink felsic volcanics.

Unit 8b is dominated by red and gray, medium to coarse grained sandstone, and minor conglomerate and siltstone. The sandstones are, in places, micaceous and calcareous, and contain gray and green reduction spots. Medium scale, trough and planar crossbeds are common. Parting lineation and intraclasts are also present.

Fining upward sequences (1-5 m thick) occur in the relatively well exposed section along Junction Brook, and are mapped (Unit 8c) separately. Medium to coarse grained sandstone and minor pebble conglomerate are present at the base of each sequence, and grade upward into siltstone. Sandstones are gray to grayish red in color, whereas siltstones are red. Parting lineations are very common in the sandstones, which are also abundantly cross-stratified (both planar and trough types). Scours and channels are abundant, and include an exhumed channel 5 m wide by 1 m deep that is preserved on a small stream north of Junction Brook. Other features noted include intraclasts, reduction spots, and fossil roots.

Unit 8d consists chiefly of fine grained red sandstone and siltstone, and forms the top portion of the North Brook Formation. The sandstones are calcareous (nodules and cements), micaceous, and contain gray and green reduction spots. Structures in these beds include dessication cracks, trough crossbeds, ripple marks, ripple cross-laminations and parallel laminations.

Also included in the North Brook Formation are limestones, which are present at the unconformity between the Deer Lake Group and Lower Paleozoic marbles. These limestones could be of any age from Ordovician to Carboniferous, but are here presumed to be Carboniferous. Two types of rudite occur. The first type contains clast-supported conglomerates and breccias in which clasts are overwhelmingly carbonate. These clasts are up to 20 cm in size, and are cemented by calcite, although in some places the clasts are set in a green sandstone matrix. The second type of rudite is a breccia, in which fragments of Lower Paleozoic marble are set in a calcareous matrix. The fragments are coated by laminated calcite. Nonrudaceous limestones at the unconformity are bituminous, laminated, brecciated and contain scattered ooids.

Paleoflow directions within the North Brook Formation vary with position in the depositional basin (Hyde, 1979). In the Junction Brook area, southwesterly to northwesterly paleocurrent directions were obtained. East of Grand Lake, paleoflow was directed towards the north and northwest, away from the basin margin. A few paleocurrent measurements from the area southwest of Glide Lake suggest paleoflow towards the northeast to northwest.

Depositional environments in the North Brook Formation are dominantly fluvial, with some alluvial fan sedimentation. Superb examples of Scott-type, braided stream deposits (Miall, 1978) occur southwest of Glide Lake. Fining upward sequences are interpreted as meandering stream deposits. On Lane's Brook, debris flow conglomerates suggest deposition on alluvial fans. These fan deposits grade upward into sandstones probably deposited within braided channels located near alluvial fan toes. Carbonate clasts cemented by calcite near the unconformity with Lower Paleozoic carbonate rocks are also regarded as alluvial fan deposits (for a recent analogue see Lattman, 1973).

In addition to calcareous fanglomerates, inferred calcretes and karstic limestones are present at the unconformity with Lower Paleozic carbonate rocks. The calcrete

limestones show a clotted texture in thin section, with peloids and disseminated ooids. These ooids contain only one or two concentric layers. In many places, micrite has recrystallized to microspar. One other characteristic microscopic feature is wispy, curvilinear zones of microspar. The calcretes are also studded with silt-size quartz grains. The carbonates deposited under karstic conditions are best exposed in a large quarry in the northwestern part of the map area. Here, the breccias with coated fragments occur. Carbonate deposits in the form of cave pearls, flowstone, and straws (speleological terms) also occur. Large fractures 50 cm wide and 1 m long and small caves up to 1 m in diameter within the Lower Paleozoic marbles are filled and lined with laminated, inorganically precipitated calcite. Other fractures in the marble are up to 15 m in length and are filled with green sandstone.

Rocky Brook Formation (Unit 9)

The Rocky Brook Formatin is estimated to be about 600 m thick on Junction Brook. We estimate a maximum thickness of about 1000 m near Island Pond Brook. In the northern part of the map area, the Rocky Brook Formation can be subdivided into two informal members; namely, the red-gray unit (9a) and the gray unit (9b). The red-gray unit contains a wide variety of lithologies which include very fine to fine grained sandstone, siltstone, mudstone and various types of limestones. The siliciclastic rocks are red, brown, gray and green, and are commonly calcareous. We observed mudcracks, cross-laminations, wrinkle marks, and bioturbation in red beds. Gray and green beds contain current ripples, cross-lamination, and bioturbation. Contacts between red/brown and gray/green strata are either gradational or sharp. We saw one erosional contact with trough cross-stratified, fine grained red sandstone cutting down into gray siltstone. Carbonate rocks are usually massive, microcrystalline limestones which, in thin sections, show homogeneous micrite in varying stages of recrystallization to microspar. Spar-filled fenestrae (bird's eye structure), which are common elsewhere in Rocky Brook limestones in the Deer Lake Basin, are rare in the 1980 map area. Some limestones show clastic textures in the form of wavy and lenticular bedding and flat-pebble conglomerates. Other laminated limestones may have had an algal origin, and some carbonates contain stromatolite-like domes.

The gray unit, which is absent in the Grand Lake area due to nondeposition, overlies the red-gray unit. The contact between them is placed at the highest occurrence of red strata. Lithologies in the gray unit are dominated by gray and green siltstones and mudstones, which are normally calcareous. These fine grained beds also contain large carbonate concretions with calcite and barite-filled shrinkage cracks, pyrite cubes and nodules, and larger sulphide nodules up to 40 cm in size. Blue-gray and chocolate-brown weathering oil shales occur along Rocky Brook. These oil shales have a light brown streak and petroliferous odor. Many different types of limestone occur in the well-exposed section along Rocky Brook. There are bands of oolitic limestone, 2-5 cm thick, containing abundant fossil fish debris (mostly scales and bones, some fins and headplates). Other limestones are microcrystalline and concretionary but form layers parallel to bedding. Finally, domical stromatolitic limestones are common with relief up to 25 cm. One bedding plane showed colonies of stromatolites two by three square metres in area distributed on the bedding plane as patches. Another bedding plane showed raised rings 10-20 cm wide of algal(?) growths varying from 30-70 cm in outside diameter.

Belt (1969) and Hyde (1979) have previously interpreted the Rocky Brook Formation as a mixed fluvial and lacustrine deposit. This interpretation can now be refined by noting the widespread presence of dessication features (mudcracks, bird's eyes) in the red-gray unit *in all rock types*. This indicates that all types of sediment were subject to periodic subaerial exposure. We interpret the red strata as sheets of fine grained alluvial sediment and soil, deposited adjacent to a lake which periodically contracted. The lacustrine deposits are mostly represented by the gray carbonates and the gray and green beds. These deposits were at times buried by red, alluvial sediment following contraction of the lake margin, and through time the alternating sequence of red, gray, and green strata with carbonates was constructed. The gray unit, however, lacks red strata and dessication features, but contains abundant fossil fish debris and oil shale. For these reasons, we interpret the lake at this period of time to be perennial, but not more expansive as suggested by Hyde (1979), for it is now realized that the gray unit is not present in the Grand Lake area. Abundant pyrite in the gray unit indicates much more reducing conditions than during the lake's ephemeral stage. Because of the presence of carbonate rocks and diagenetic calcite in the siliciclastic lithologies, the entire hydrologic system in the basin was decidedly alkaline.

Humber Falls Formation (Unit 10)

In the Deer Lake area, this formation consists of light green and gray, pebble conglomerates, and red and gray, fine to very coarse grained sandstones. Pebbles in the conglomerate range up to 15 cm in apparent long axis. Many of the pebbles are sedimentary rocks, such as green, red, and gray sandstones, dark gray siltstones, and pink limestones. The source of these sedimentary clasts cannot be pinned down, but the presence of sedimentary clasts represents a marked difference in pebble composition from the Humber Falls Formation conglomerates farther north, where volcanic clasts are abundant (Hyde and Ware, 1980). Sandstones in the Humber Falls Formation in the Deer Lake map area are extensively cross-stratified and parallel-laminated, and are inter-lensed with the conglomerate. A maximum thickness of 250 m is assigned to the Humber Falls Formation (Hyde and Ware, 1980).

Paleocurrent measurements on some crossbeds yielded paleo- currents towards the southeast to south-southwest. Fifteen measurements on parting lineations revealed a bimodal pattern with line of motion modes oriented northeast-southwest and nortwest-southeast. It is unclear whether this change in paleoflow direction was related to time or due to areal position.

We interpret the Humber Falls Formation as a fluvial deposit. The presence of trough crossbeds up to 3 m in thickness indicates that channels were of considerable depth and, by implication, of substantial width. By combining the paleocurrent measurements above with those obtained in 1979 (Hyde and Ware, 1980), it becomes apparent that paleoflow orientations were quite variable. In light of all the available data, we feel the most plausible type of fluvial system is that of a coarse grained, meandering type (see Nijman and Puigdefabregas, 1978 for an ancient example).

Howley Beds (Unit 11)

The Howley Beds consist of conglomerates, sandstones, siltstones, mudstones, minor limestones, and coals. Based on spore assemblages these strata appear to range in age from Visean/Early Namurian to Westphalian A (Hacquebard *et al.*, 1960; Belt, 1969; p. 741; Barss, 1980, personal communication). It is likely, however, that deposition was

intermittent rather than continuous during this time interval. A thickness estimate is difficult to establish for the Howley Beds but, for the area northeast of Howley, Hyde (1979) suggested at least 3100 m if there was no repetition of strata. Previous workers (Belt, 1965; Baird, 1959) have mapped the Howley Beds only on the eastern side of Grand Lake. However, there are rocks in two areas on the western side of the lake which we interpret as belonging to the Howley Beds. Strata in the more southern of these two areas gradationally overlie the red-gray unit of the Rocky Brook Formation. Subdivision of the Howley Beds is based on the presence of poorly defined, fining upward sequences (11a) and well defined fining upward sequences (11b).

Unit 11a is characterized by a wide diversity of rock types. Red and, to a lesser extent, gray pebble conglomerates are present, with clasts up to 20 cm. Clasts are mainly felsic and mafic volcanic rocks, muscovite granitic rocks, orange feldspars, and quartz. Quartz is the most abundant clast rock type in granule and fine-pebble conglomerates. Red cobble-boulder conglomerates, with clasts up to 50 cm, were seen twice near the contact with pre-Carboniferous rocks. Conglomerates in Unit 11a are usually massive, but some are cross-stratified.

Sandstones are predominantly gray, friable, and medium to coarse grained, but sandstones of all grain sizes occur and, in addition to a gray color, may be red, pink, green, tan, brown, and cream. The sandstones are petrographically diverse. They may be micaceous, feldspathic, or calcareous; others are ferruginous, bituminous, or pyritiferous. Trough and planar crossbeds are common, and range up to 1.2 and 2.3 m in thickness, respectively. Coarse grained sandstones are thickly bedded and, together with conglomerates, have erosive, basal contacts. We observed straight-crested ripples and ripple cross-lamination in fine grained sandstones and a preserved megaripple. Parallel lamination is also present and is particularly abundant in medium grained, green, micaceous sandstone. Three types of nodules are present in sandstone: (1) ironstone (common, especially between Hinds Brook and Howley), (2) calcite (rare), and (3) pyrite (rare). The ironstone nodules range up to 75 cm in size, but are usually no larger than peas. Some of the ferruginous nodules appear to be a carbonate mineral (perhaps siderite). Iron-rich, fine grained sandstones occur near the tops of fining upward sequences north of Little Pond Brook. Plant debris, bark impressions and coalified wood chips are also common in the sandstones.

Siltstones and mudstones may be red, gray, and green, and some are micaceous. We noticed mudcracks, rootlets, and reduction spots in red siltstones and mudstones. Some beds of dark gray mudstone are extremely carbonaceous. Carbonate rocks occur only on the western side of Grand Lake as very thin beds of microcrystalline limestone.

At some outcrops, the strata are organized into fining upward sequences, but their vertical stratigraphic extent is unknown due to poor exposure. At other outcrops, there is no obvious organization to the beds.

In Unit 11b, however, the strata are arranged into well defined, fining upward sequences. Here, sharp-based, gray and red-gray, medium to coarse grained sandstone, pebbly sandstone, and conglomerate consistently grade upward into red, fine grained sandstone and siltstone. Conglomerates contain clasts up to 3 cm of quartz, mafic volcanic rocks, jasper, and intraclastic siltstone. The sandstones are massive, small to large scale, planar and trough cross- stratified, (sets up to 1 m thick), and parallel laminated. One distinctive type of sandstone is red and fine grained, and contains trough

cross-laminations, outlined by concentrations of hematite. Plant and wood debris are not uncommon in the sandstones. Siltstones and mudstones are red, and contain reduction spots and calcrete nodules and layers.

Measurements of trough and planar crossbeds on the eastern side of Grand Lake both show consistent westerly paleoflow. Measurements of four trough axes on the western side of Grand Lake opposite Hinds Brook yielded paleoflow towards the northeast. A few measurements on strata of Unit 11b gave highly variable results, such that we are unable to determine the general sediment transport direction for these rocks.

Belt (1969) and Hyde (1979) had earlier interpreted the Howley Beds to be mainly fluvial in origin. The fining upward sequences in Unit 11b are clearly the result of meandering stream deposition. Less clear is the paleochannel configuration associated with the deposition of Unit 11a. There is too much mud for normal braided stream deposition, so that we favor a more meandering channel pattern, probably with coarse grained point bars. Cobble-boulder conglomerates near the contact with pre-Carboniferous rocks may reflect braided channel or alluvial fan deposition. The very carbonaceous mudstones and coals were most likely deposited within swampy floodplain areas.

STRUCTURAL GEOLOGY

FAULTING

Four major northeasterly trending faults occur in the map area. These are, from east to west : (1) the Grand Lake Fault, (2) the Cabot Fault, (3) the Glide Mountain Fault, and (4) the Deer Lake Fault.

The Grand Lake Fault forms the eastern margin of the Deer Lake Basin, and the fault is marked by a prominent break in slope. Outcrops of the Howley Beds adjacent to the Grand Lake Fault commonly display slickensided surfaces, fracturing, and recrystallization.

Outcrops are few close to the Cabot Fault in inland areas, but the fault probably passes very close to continuous exposures along the western shoreline of Grand Lake north of 35th Brook. Here, the effects of the fault are plainly visible in the arkose unit of the Anguille Group. Arkoses are recrystallized, cleaved, and veined with calcite. It is unclear where the Cabot Fault emerges from the north end of Grand Lake to connect with its extension near the north end of the map area.

Popper (1970) first mapped and described the effects of the Glide Mountain Fault (the southwestward extension of the Birchy Ridge Fault, Hyde, 1979; Hyde and Ware, 1980). In terms of its deformational and metamorphic effects on adjacent rocks, the little-known Glide Mountain Fault must rank alongside the well-known Cabot Fault. The effects of the Glide Mountain Fault (shearing, slickensided surfaces, and veining) are well displayed on Horseshoe Brook.

The Deer Lake Fault is poorly defined in the map area, and there is no evidence of its presence east of Deer Lake townsite. Either it simply terminates, or reactivation of the fault following burial by the Deer Lake Group did not extend to a point east of Deer Lake townsite. A splay off the Deer Lake Fault separates the North Brook Formation from quartz-mica schists of the Fleur de Lys Supergroup. Also, close to this fault along Lane's Brook there are small, westward dipping thrust faults contained within conglomerates of the North Brook Formation.

FOLDING

Two different fold styles are present in the map area. The first type is restricted to that portion of the Glide Mountain block flanked by the Cabot and Glide Mountain Faults and underlain by the Anguille Group. Here,

parallel folds are oriented such that fold axes are oblique to fault traces. The folds can be small, with wavelengths less than 1 m, or be regional in scale. They tend to be tight, although one regional fold, termed the 39th Brook Syncline, is more open. Folds near the Grand Lake shoreline invariably plunge southward at moderate angles, whereas those on Johnson's Brook plunge northward. Fifty measurements on minor folds showed that 43 had axial planes dipping vertically or to the west.

In contrast, folds elsewhere in the map area are much more open, even in the Anguille Group. Also, these folds plunge northeastwards at shallow angles, and are folded about axes that are subparallel, rather than oblique, to fault traces. It is also noteworthy that the syncline cored by the Humber Falls Formation (Humber River Syncline) has its axial plane dipping southeastwards, whereas an inferred syncline passing up through the centre of Grand Lake has its axial plane dipping northwestwards.

It is difficult to interpret this diversity in fold orientation and style in terms of a single or multiple, *basinwide*, compressional event. For this reason, the folding is inferred to have been the result of fault movements (*see also* Belt, 1969; Popper, 1970; and Hyde, 1979). For reasons cited in Hyde (1979), we interpret the folds that are oblique to fault traces to be the result of strike-slip faulting along the Cabot and Glide Mountain Faults. The greater intensity of folding in the segment of the Glide Mountain block flanked by the above faults cannot easily be reconciled in terms of more intense folding at a lower crustal level because pre-Carboniferous basement rocks are exposed northwest of the Glide Mountain Fault where folds have an open style. Thus, we attribute the differences in intensity to contrasts in competency. Although there is little evidence of refolding of the relatively tight folds between the Cabot and Glide Mountain Faults, we interpret the more open, gently plunging folds as occurring at a later time, and as the result of dominantly vertical fault movements.

ECONOMIC GEOLOGY

URANIUM

Thirty-six radioactive anomalies (not all shown on map) were detected with a Scintrex BGS-1 scintillometer in the 1980 map-area. Of these, twenty-seven occur in the Rocky Brook Formation. These anomalies are presumed to be due to uranium, since previous assays of Rocky Brook Formation anomalies have shown them to be uraniferous (although in some cases there is apparent disequilibrium between uranium and its daughter products). Most of the anomalies in the Rocky Brook Formation are associated with gray and green siltstones and mudstones, but some are in limestones. These anomalies are all stratiform, and are ordinarily two to five times background and 20-50 cm thick. In terms of grade and thickness, the best anomaly is six times background over a distance of 1.2 m; it occurs south of Island Pond Brook along the western shoreline of Grand Lake. We detected six anomalies (again presumed to be due to uranium) near the unconformity between the Lower Paleozoic carbonates and karstic limestones, calcretes, and carbonate fanglomerates of the North Brook Formation. These anomalies are, in places, associated with solid bitumen in the rock. Two weak anomalies were encountered in limestones of the Howley Beds and one weak anomaly was detected in sandstone of the Anguille Group. Relatively high scintillometer readings (150-250 counts per second) were routinely found in the Silurian-Devonian felsic volcanic rocks.

BASE METALS

Numerous gossans occur in the Howley Beds along the western side of Grand Lake. One of these gossans contains a few grains of chalcopyrite associated with plant material in a sandstone at

the base of a fining upward sequence. Approximately 100 m northeast of this occurrence, along the shoreline, we discovered a float block of red sandstone containing malachite, bornite, and scattered grains of chalcopyrite and pyrite. One of the gossans could be traced for about 70 m along structural strike. A gossan near the base of the Howley Beds contained two unidentified secondary minerals. One mineral was yellowish green and earthy; the other was clear and acicular.

BITUMEN

Solid bitumen occurs as veins and fracture fillings in Lower Paleozoic carbonates and in basal carbonates of the North Brook Formation. Solid bitumen also occurs as pore fillings in gray sandstones of the Howley Beds. Although locally quite rich, bituminous zones in the Howley Beds are less than 1 m thick with little apparent lateral extent.

OIL SHALE

Oil shales are most abundant in the gray unit of the Rocky Brook Formation, and are well exposed along Rocky Brook. The oil shale layers are usually less than 1 m thick but, at one locality, a 2 m thick section contained 1.6 m of oil shale.

COAL

Although coal seams are known to occur in the Howley Beds (Hayes, 1949), we observed no coal *in situ* within the Howley Beds. However, large fragments of coal occur along the bed of Alder Brook, and we also observed coal fragments along Coal Brook and an unnamed brook between Hinds and Alder Brooks. An old coal dump is present along a trail south of Coal Brook close to a trench like excavation. This dump and excavation are probably associated with coal mining early in this century (Hayes, 1949).

ACKNOWLEDGEMENTS

We acknowledge the very capable field assistance and boatmanship rendered by Hazen Russel and John Blagdon. We also thank Jim Barrett and Sid Parsons for their logistical support. Gratitude is extended to Bowater Newfoundland Ltd. and Shawmont Newfoundland Ltd. for use of their roads. Colin Klappa and Noel James pointed out many of the paleokarstic features to us in the field. Ian Knight and Steve Colman-Sadd reviewed the manuscript.

REFERENCES

Baird, D.M.
1950: Oil shales of the Deer Lake region. Geological Survey of Newfoundland, Unpublished report, 23 pages.

1959: Geology, Sandy Lake (west half), Newfoundland. Geological Survey of Canada, Map 47-1959, Scale, 1:250,000.

Belt, E.S.
1965: Geologic map, Deer Lake Basin, Unpublished. Scale 1:250,000.

1969: Newfoundland Carboniferous stratigraphy and its relation to the Maritimes and Ireland. American Association of Petroleum Geologists, Memoir 12, pages 734-753.

Fleming, J.M.
1970: Petroleum exploration in Newfoundland and Labrador. Department of Mines and Energy, Mineral Development Division, Report 3, 118 pages.

Hacquebard, P.A., Barss, M.S., and Donaldson, J.R.
1960: Distribution and stratigraphic significance of small spore genera in the Upper Carboniferous of the Maritime Provinces of Canada.

Fourth International Carboniferous Stratigraphy and Geology Congress, Heerlen, 1958, Compte Rendus, volume 1, pages 237-245.

Hayes, A.O.
1949: Coal possibilities of Newfoundland. Geological Survey of Newfoundland, Information Circular 6, 15 pages.

Hyde, R.S.
1979: Geology of Carboniferous strata in portions of the Deer Lake Basin, western Newfoundland. Department of Mines and Energy, Mineral Development Division, Report 79-6, 43 pages, 5 geologic maps. Scale 1:50,000.

Hyde, R.S. and Ware M.J.
1980: Geologic map with marginal notes, Cormack-Silver Mountain area. Department of Mines and Energy, Mineral Development Division, Map 8011, Scale 1:50,000.

Lattman, L.H.
1973: Calcium carbonate cementation of alluvial fans in southern Nevada. Geological Society of America Bulletin, volume 84, pages 3013-3028.

Miall, A.D.
1978: Lithofacies types and vertical profile models in braided river deposits: a summary. Canadian Society of Petroleum Geologists, Memoir 5, pages 597-604.

Nijman, W. and Puigdefabregas, C.
1978: Coarse-grained point bar structure in a molasse type fluvial system, Eocene Castisent Sandstone Formation, South Pyrenean Basin. Canadian Society of Petroleum Geologists, Memoir 5, pages 487-510.

Popper, G.H.P.
1970: Paleobasin analysis and structure of the Anguille Group, west-central Newfoundland. Ph.D. thesis, Lehigh University, Bethlehem, Pennsylvania, 215 pages.

Taylor, R.P., Strong, D.F., and Kean, B.F.
1980: The Topsails igneous complex: Silurian-Devonian peralkaline magmatism in western Newfoundland. Canadian Journal of Earth Sciences, volume 17, pages 425-439.

Werner, H.J.
1955: The geology of Humber Valley, Newfoundland. Newkirk Mining Corporation, summary and final report, 116 pages.

GEOLOGY OF THE KING GEORGE IV MAP AREA, (12A/4), NEWFOUNDLAND

by

B.F. Kean and N.R. Jayasinghe

INTRODUCTION

The King George IV map area in southwest Newfoundland was mapped at a 1:50,000 scale during the 1980 field season. The newly constructed Burgeo highway runs approximately north-south through the centre of the area; however, access to most of the area is by aircraft. A number of large ponds and lakes scattered over the area provide easy access by float plane. Victoria River is easily navigable by canoe from Peter Strides Pond to approximately 3 km above Victoria Lake.

The area was mapped previously by Riley (1957) at a 1:253,440 scale. DeGrace (1973) mapped the area in the vicinity of King George IV Lake. Smyth (1979) produced a 1:50,000 scale compilation of the geology of the area based on his reconnaissance mapping and data from the Buchans Mining Company. Hudson Bay Oil and Gas Company carried out reconnaissance geological mapping in the area in 1979.

The rocks in the King George IV map area can be readily divided into five groups; namely, (1) gneiss and amphibolite, (2) ophiolite, (3) metasediments and migmatite, (4) volcanic and sedimentary rocks, and (5) gabbroic to granitic intrusions. These are briefly described below.

DESCRIPTION OF ROCK UNITS

Unit 1 - Cormacks Lake Complex

The name Cormacks Lake Complex was informally used by Herd and Dunning (1979) for an assemblage of granite, paragneiss and amphibolite in the southwestern part of the Puddle Pond map area (12A/5). A similar assemblage of rocks occupies the northwestern part of the King George IV map area, immediately to the south of 12A/5, and is also referred to the Cormacks Lake Complex. These rocks are bounded to the south and east by younger intrusions.

The Cormacks Lake Complex in this map area consists of biotite gneiss, quartzite, amphibolite, minor mica schist and calc-silicate rocks (Subunit 1a) and a foliated granite (Subunit 1b). The gneiss is pale gray and exhibits a thin (1 to 5 mm wide) banding produced by alternating biotite-rich and quartzofeldspathic layers. Garnet is common in places. Locally, the gneiss is rusty weathering, probably due to the presence of magnetite and pyrite. The quartzite is medium grained, pale gray and generally massive. The amphibolite is medium grained, greenish gray and in places contains a 2-5 mm thick layering produced by dark amphibole-rich layers and whitish to reddish quartzofeldspathic layers. Locally, the amphibole crystals (probably gedrite) range up to 4 cm in length. The foliated granite (Subunit 1b) outcrops adjacent to the western margin of the map area. It is reddish, medium grained and cut by thin (<1 m in width) diabase dikes that have been deformed with the granite.

Evidence of polyphase deformation is common in Unit 1. For example, in outcrops of the foliated granite, a north-northwest trending foliation has been transposed to a northeasterly one. In the gneisses, Type 1 and Type 3 interference patterns are common and the northwest trending banding, foliation and earlier folds have been folded around northeast trending fold axes. The second folds are generally tight to isoclinal and have a northeast striking axial planar foliation. This foliation

is in turn openly folded around northwest trending, steeply plunging fold axes.

No radiometric dates are available from the Cormacks Lake Complex. Herd and Dunning (1979) have suggested a Grenvillian age for the complex.

Unit 2 - Ophiolite

Unit 2 is exposed in a number of fault bounded blocks bordering the southeast side of King George IV Lake. It consists of gabbro and sheeted dikes (Subunit 2a) and basaltic pillow lava (Subunit 2b) and represents the upper part of an ophiolite. It is probably a part of the Annieopsquotch ophiolite complex (Dunning and Herd, 1980) from which it is now separated by faulting and younger rocks but, unlike the Annieopsquotch ophiolite complex, which faces southeast, Unit 2 faces west.

Subunit 2a makes up approximately 50 percent of the unit and is composed of diabase dikes and fine to medium grained, equigranular to locally feldsparphyric gabbro. The diabase dikes vary from isolated to sheeted, fine to medium grained, and aphyric to feldsparphyric. They have chilled margins and an average thickness of 0.5 m (in places up to 10 m). They trend north to northwest and dip moderately to steeply eastwards. Epidote veining is common. Much of the medium grained gabbro between the fine grained dikes probably represents parts of large dikes that range up to 10 m in thickness.

Subunit 2b is composed of basaltic pillow lava and minor pillow breccia. The pillow lava is fine grained, green, rarely vesicular and varies from aphyric to feldsparphyric. In places, it is highly epidotized. The individual pillow structures range from perfectly rounded to bun and toe shaped and measure 15 cm to 1.5 m across. The smaller pillows are generally more rounded than the larger ones. Most of the pillows have a thin selvage and are generally closely packed with little interpillow material which, where present, is red and rarely green chert or aquagene tuff. Thin beds (1-2 cm, some up to 30 cm thick) of mafic tuff were found associated with the pillow lava in places. In a few outcrops, the pillow lava has been intruded by diabase dikes.

For the most part, Unit 2 appears to be undeformed. However, in places, it is cut by northwest trending 2-5 cm wide shear zones, which are intensified in fault zones.

Unit 2 is considered to be part of the oceanic basement on which the Middle Ordovician Victoria Lake Group (Unit 4) was deposited.

Unit 3 - Sedimentary rocks, metasediments and migmatite

Unit 3 occupies much of the southwestern and the central parts of the King George IV map area. It has been divided into four subunits (3a, 3b, 3c and 3d) on the basis of rock type. Subunit 3a, north of Peter Strides Pond, is bordered to the north by the Rogerson Lake Conglomerate (Unit 5), but the contact relationships are not known; it is intruded by Subunit 9c in the extreme southeast corner of the map area. Thinly bedded (<3 cm in width) gray, green and black argillite, slate and mudstone with thin interbeds and lenses of sandstone, locally tuffaceous, constitute Subunit 3a. The bedding has a northeasterly strike and steep dips. South of Victoria River, the metamorphic grade increases with the development of chlorite schists and garnet-biotite schists. These have been designated as Subunit 3b. Subunit 3b has been intruded by granitic rocks of Unit 6.

Subunit 3c occurs in the southwestern part of the map area, where it is separated from Unit 7 to the north by a major fault. In the south, it grades into migmatite of Subunit 3d. A linear, northeast trending granitic intrusion (Unit 6) has divided Subunit 3c into two

LEGEND

DEVONIAN AND YOUNGER

11 *Medium to coarse grained, massive, hornblende, biotite gabbro*

10 *Medium grained, weakly foliated, biotite granite*

9 *Massive to locally foliated granite, diorite and minor gabbro:* 9a, *Fine to medium grained diorite and minor gabbro;* 9b, *equigranular to megacrystic (K-feldspar), hornblende-biotite granite;* 9c, *megacrystic (K-feldspar), biotite granite with minor, equigranular, biotite and "two-mica" granites (locally garnetiferous)*

8 *Gabbro, diorite, monzogabbro, monzodiorite and minor granitic rocks*

DEVONIAN AND OLDER

7 *Conglomerate and volcanics:* 7a, *Purple to gray, pebble to boulder conglomerate with intercalated sandstone, argillite, and minor limestone;* 7b, *green mafic volcanics;* 7c, *red, flow-banded rhyolite, breccia, feldspar porphyry, and tuff; red crossbedded sandstone, siltstone and minor conglomerate*

6 *Granite and granodiorite:* 6a, *Reddish, medium grained, foliated biotite granite;* 6b, *gray, medium grained, foliated granodiorite*

5 ROGERSON LAKE CONGLOMERATE: *Gray to purple polymictic conglomerate and minor sandstone*

ORDOVICIAN AND OLDER

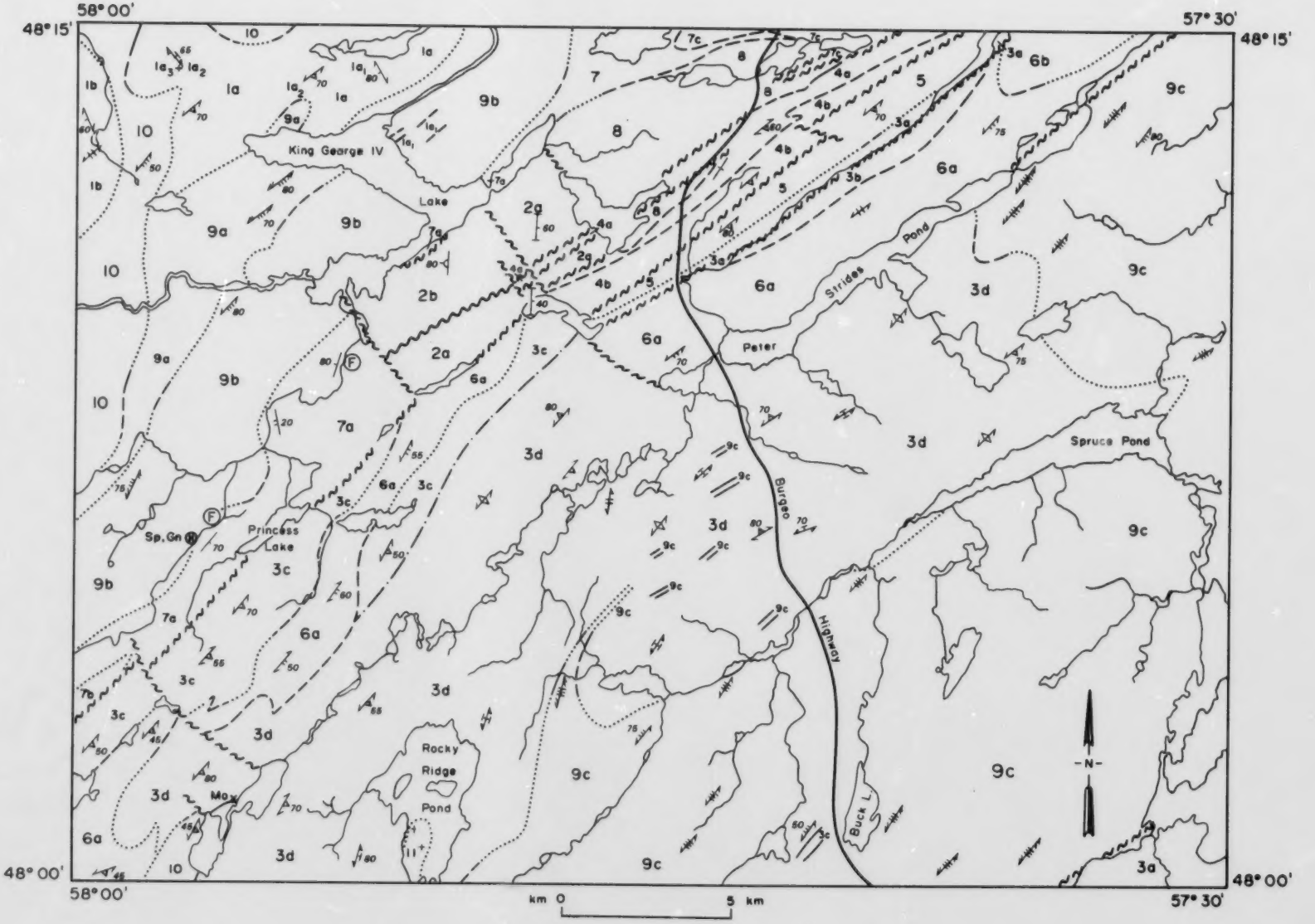
4 VICTORIA LAKE GROUP: 4a, *Mafic to intermediate pillow lava, breccia, agglomerate, and tuff;* 4b, *intermediate to silicic tuff, breccia, minor quartz (feldspar) crystal tuff, and unseparated graywacke and shale*

3 *Sedimentary and metasedimentary rocks and migmatites:* 3a, *Slate, argillite, graywacke, and minor mafic and felsic tuff;* 3b, *mica schist, chlorite schist, semipelitic schist, and minor mafic and felsic tuff;* 3c, *quartzite, mica schist, semipelitic gneiss, metasediments, and minor amphibolite;* 3d, *migmatite, granodiorite, and unseparated granitic sheets*

2 *Sheeted dikes, gabbro and pillow lava:* 2a, *Sheeted dikes and fine to medium grained gabbro;* 2b, *mafic pillow lava and breccia*

1 CORMACKS LAKE COMPLEX: $1a_1$, *Medium grained, pale gray quartzite;* ($1a_2$), *medium to coarse grained, gray amphibolite;* ($1a_3$), *coarse grained mica schist and gneiss;* 1b, *medium grained, reddish, foliated grainte*

Mylonite foliation related to S_3 (inclined, vertical) . . . . .


58° 00'
57° 30'
48° 15'
48° 00'
King George IV Lake
Princess Lake
Sp. Gn
Rocky Ridge Pond
Max
Strides Pond
Peter
Spruce Pond
Burgeo Highway
Buck L
N
km 0
5 km

separate belts. Semipelitic metasediments, gneiss and mica schist are the predominant rock types in Subunit 3c. It also contains minor quartzite, amphibolite and calc-silicate rocks. The metasediments are medium grained, pale gray and either massive or contain a weak foliation and banding. The gneiss shows a millimetric banding produced by quartz-rich layers and micaceous layers. The biotite schists are coarse grained and commonly contain garnet and staurolite.

Subunit 3d, consisting of pale gray, medium to coarse grained, crudely to moderately banded (2 to 20 mm wide) migmatite, occupies much of the southern part of Unit 3 and is well exposed along the Burgeo highway. Intercalated with the migmatite are 0.5 m to a few tens of metres wide granodiorite and granitic sheets. The migmatite has a granodioritic to tonalitic mineralogy and locally grades into massive-looking granodiorite sheets. In places, angular to lensoid blocks of amphibolite and psammitic rocks occur within the migmatite and are considered to represent parts of premigmatitic terrain.

The most common structures in Unit 3 are the northeast striking, moderately to steeply dipping banding and foliation. The foliation is axial planar to tight to isoclinal minor folds of the banding in the gneisses and the migmatites. It also overprints the granodioritic and most of the granitic sheets that are intercalated with the migmatite and becomes mylonitic in places. This foliation seems to predate a set of west-northwest to northwest trending open folds, kink bands and minor shear zones.

Unit 3 can be correlated both in rock type and regional stratigraphy with the metasedimentary-migmatite terrains in the southern part of Noel Paul's Brook, Lake Ambrose and Victoria Lake map areas (Kean, 1977; Kean and Jayasinghe, 1980) and the Granite Lake area (Dickson, this volume). The unit is pre-Devonian since deformed metasedimentary clasts that are most likely to have been derived from the unit occur in Lower Devonian conglomerates (Unit 7) in the area.

Unit 4 - Victoria Lake Group

Unit 4 is a narrow (< 2.5 km in width) northeast trending band of volcanic rocks and minor sedimentary rocks in the northern part of the map area. It is a southwesterly extension of the Middle Ordovician and older (?) Victoria Lake Group (Kean, 1977) in central Newfoundland. Unit 4 is faulted against the Rogerson Lake Conglomerate (Unit 5) to the south. A fault contact with Unit 2 and an intrusive contact with Unit 8 define its northern limit. Parts of the unit are well exposed along the Burgeo highway.

Unit 4 can be divided into two subunits (4a and 4b) on rock type. Subunit 4a consists mainly of dark green to apple green, fine grained mafic pillow lava. The pillows are generally round and less than 0.5 m in diameter with selvages varying from 0.5 to 1 cm in thickness. The pillows generally display a low degree of vesicularity. Interpillow material is rare and, where present, is aquagene tuff. Minor intercalated units of bedded mafic tuff are found in places. The pillow lava is overlain to the north by fine grained mafic tuff and intercalated mafic and felsic tuff. The individual tuff beds are generally less than 2 cm in thickness and are locally intercalated with rare beds of red argillite. Locally, felsic volcanics containing quartz "eyes" are present and are probably crystal tuffs. Gray chert, similar to that associated with the Annieopsquotch ophiolite complex (Dunning, personal communication, 1980), occurs in the extreme northeast of the subunit. The proportion of mafic to felsic tuffs varies from outcrop to outcrop but, overall, the mafic rocks predominate over the felsic. In places, fault slivers of red sandstone, conglomerate and massive, mafic lava (Unit 7) occur within the unit.

Subunit 4b consists of intermediate to felsic tuff, lapilli tuff, breccia and sericite schist derived from them. These range in color from green to buff and white. The tuffs are generally aphanitic to fine grained and are mostly quartz-feldspar crystal tuffs and crystal-lithic tuffs. The lapilli tuff and breccia contain angular to subrounded clasts of white weathering, green to gray chert, dacite and rhyolite, minor mafic volcanic and rare red chert. The clasts range from a few millimetres to 30 cm in size and are set in a fine to medium grained tuffaceous sandstone matrix composed of quartz, feldspar and lithic fragments. These rocks grade into the fine grained tuffs and are interbedded in places with green and gray-black argillite and slate. Locally, mafic volcanics and quartz-eye rhyolite occur interbedded with the above rocks. Unit 4 is intruded by undeformed gabbro and diabase.

The unit is variably deformed; in places the rocks are highly foliated whereas in other places they are massive. The foliation strikes northeasterly and dips steeply.

Unit 5 - Rogerson Lake Conglomerate

Unit 5 is a southwesterly extension of the Rogerson Lake Conglomerate in central Newfoundland (Kean and Jayasinghe, 1980). It consists mainly of grayish to purplish, polymictic conglomerate. Intercalated with the conglomerate are up to 1 m thick beds and lenses of sandstone. The clasts in the conglomerate are mostly subrounded to rounded and consist of mafic and felsic volcanics, red and gray chert and sandstone, gray siltstone, black argillite and shale, and minor granite and porphyry. The matrix is gray to red sandstone which is arkosic in places.

Unit 5 contains a strong northeast trending fabric which is in part related to faulting. Clasts become flattened and attenuated to the south as a major fault is approached.

Unit 6 - Granite and granodiorite

Unit 6 consists of two linear intrusive bodies that have been emplaced into Unit 3. The westerly of the two extends from the southwestern corner of the map area to the center of the area and consists of red medium grained granite (Subunit 6a). The other occurs north of Peter Strides Pond and consists of red medium grained granite (6a) and pale gray, medium grained granodiorite (6b). Subunit 6b is interpreted to be a phase of 6a.

Unit 6 postdates the banding in the country rocks because apophyses of the granites truncate the gneissic banding in Unit 3. Large (up to 3 cm long) cordierite crystals occur in pelitic rocks adjacent to the westerly intrusion and are believed to be related to the granite emplacement. Unit 6 contains a strong foliation, defined by quartz and mica. The foliation strikes in a northeasterly direction and is generally mylonitic. Unit 6 was intruded postmylonitization by subunit 9c.

Unit 7 - Conglomerate, sandstone and volcanic rocks

Unit 7 occupies a 1 to 2.5 km wide belt that extends from the southwestern part of the map area to northeast of King George IV Lake. It has been divided into three subunits, 7a, 7b and 7c. Subunit 7a consists of gray, locally red, granule to boulder conglomerate and minor interbedded sandstone. The conglomerate is clast supported, unsorted and unstratified. Grading is common. The clasts are subangular to rounded and consist of red and gray chert, massive and foliated granite, gabbro, mafic volcanics, flow banded rhyolite, quartz-feldspar porphyry, felsic tuff, vein quartz, black argillite, rare paragneiss with folded banding, and a reddish brown weathering rock that could be ultramafic. The sandstone interbeds vary from a few centimetres to 1 m in width and commonly show cross-bedding. The contacts between

the sandstone beds and the overlying conglomerate beds show scour and fill features. In places, up to 1 m thick, black argillite beds were found in the unit. These contain plant fossils, located on a brook southwest of King George IV Lake, that have been tentatively dated as Lower Devonian (W.B. Forbes, personal communication, 1980).

Subunit 7b consists of dark green, mafic volcanics. They show weakly developed pillow structures, are highly vesicular and are locally rich in pyrite. Subunit 7c is composed mainly of red, minor black, flow banded rhyolite, rhyolite breccia, and vitric tuff and lesser sandstone, conglomerate and siltstone. The rhyolite is commonly feldsparphyric and contains calcite-filled vugs. The breccia contains angular to rounded clasts of rhyolite, felsic tuff and minor gabbro and sandstone, set in a matrix that varies from red siltstone to rhyolite and vitric tuff. The clasts range from 0.5 to 30 cm. Red sandstone beds up to 0.75 m thick showing cross-bedding, ripple marks and mud cracks overlie the felsic volcanics. Conglomerate beds ranging up to 15 cm in thickness and thinner beds of siltstone occur interbedded with the sandstone.

Unit 7 is openly folded (locally overturned) without an associated penetrative fabric; however, the sandstone and argillite beds contain a northeast trending, steeply dipping cleavage, spatially associated with faults.

Unit 8 - Gabbro and diorite

Unit 8 has been emplaced into the Victoria Lake Group and Unit 7 in the northern part of the map area. It is in assumed fault contact with the ophiolitic rocks (Unit 2) in the west. The unit is composed of medium grained, locally feldsparphyric, gabbro, diorite, quartz diorite, monzodiorite, monzogabbro, minor granitic differentiates, and granite. The monzodiorite is distinctive because of its red mottled appearance imparted by K-feldspar crystals. Diabase dikes intrude these rocks. No penetrative tectonic fabric was seen in the unit but, locally, it has been sheared along minor faults.

Unit 9 - Granite and minor hornblende gabbro and diorite

Unit 9 occupies the whole of the southeastern part and much of the northeastern and the northwestern parts of the area. It comprises a variety of rock types including hornblende gabbro and diorite, K-feldspar megacrystic biotite (± hornblende) granite and biotite (± muscovite) granite. Subunit 9a is a gray, medium grained, variably deformed, hornblende gabbro and diorite that is gradational into gray, equigranular to K-feldspar megacrystic, hornblende-biotite granite (9b) in the western part of the area. Subunit 9c is a K-feldspar megacrystic, locally equigranular, biotite granite intruded by garnetiferous, two-mica leucogranites. All of the above rocks were intruded posttectonically by undeformed, fine grained, white and pink granite and aplite dikes, and tourmaline bearing pegmatites.

Unit 9 is variably deformed. It is cut by a steeply dipping, northeast striking, mylonitic foliation in the vicinity of some of the major shear zones in the area (*e.g.* near Peter Strides Pond and Buck Lake). The mylonitic fabric is defined by elongate quartz grains and biotite flakes and is wrapped around deformed feldspar crystals. Sheets of Unit 9 intrude the migmatites (Unit 3) and have been folded with the development of an axial planar fabric. Apart from these areas, Unit 9 appears to be undeformed.

Unit 10 - Granite

Unit 10 comprises two intrusive bodies close to the western margin of the map area. The larger of the two has intruded Units 1 and 9. The other has been emplaced into Units 3 and 6. Unit

10 consists of medium grained, red, mafic-poor granite. The main mafic mineral is biotite, however, in one outcrop, adjacent to the southern margin of the map area, orthopyroxene crystals with amphibole rims occur. Muscovite was seen in places. Except for a weak northeast trending L>S fabric defined by quartz and mica seen in a few outcrops, Unit 10 appears to be massive.

Unit 11 - Biotite-hornblende gabbro

Unit 11 is a small body of unfoliated, medium to coarse grained, biotite-hornblende gabbro exposed on a few islands and along the shore in the southern part of Rocky Ridge Pond.

ECONOMIC GEOLOGY

The most significant mineralization in the area is associated with the Victoria Lake Group and the granitic rocks of Units 9 and 10. Except for minor pyrite and magnetite showings, no economic mineralization was found in the other units, although the ophiolitic rocks of Unit 2 have a potential for Cyprus-type massive sulphides.

In the Victoria Lake Group, disseminated pyrite and minor chalcopyrite and sphalerite occur associated with the felsic volcanic rocks.

Float of altered green granite, similar to the marginal phase of Subunit 9b, containing galena, sphalerite, pyrite and gold associated with quartz veins occurs southwest of Princess Lake*. Float of Unit 10 containing disseminated molybdenite occurs west of Rocky Ridge Pond.

* Assays: 5% Zn, 1.5% Pb, 42 ppm Cu, 25 ppm Au (average of 5 assays), 8 ppm Ag.

ACKNOWLEDGEMENTS

We thank Jerome Cole, David Evans and Ralph Skinner for their assistance in the field. We are also grateful to the support staff, Wayne Ryder, Sid Parsons and Jim Barrett, of the Newfoundland Department of Mines and Energy. Scott Swinden, Steve Colman-Sadd and Lawson Dickson kindly read the manuscript.

REFERENCES

DeGrace, J.R.
1973: Notes on the geology of the King George IV Lake area, southwest central Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Unpublished report.

Dunning, G.R. and Herd, R.K.
1980: The Annieopsquotch Ophiolite Complex, southwest Newfoundland, and its regional relationships. *In* Current Research, Part A, Geological Survey of Canada, Paper 80-1A, pages 227-234.

Herd, R.K. and Dunning, G.R.
1979: Geology of the Puddle Pond map area, southwestern Newfoundland. *In* Current Research, Part A, Geological Survey of Canada, Paper 79-1A, pages 305-310.

Kean, B.F.
1977: Geology of the Victoria Lake map area, southwestern Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 77-4.

Kean, B.F. and Jayasinghe, N.R.
1980: Geology of the Lake Ambrose (12A/10) - Noel Paul's Brook (12A/9) map areas, central Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-2.

Riley, G.C.
1957: Red Indian Lake (west half), Newfoundland. Geological Survey of Canada, Map 8-1957.

Smyth, W.R.
1979: King George IV Lake, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Map 7956.

GEOLOGY OF THE BURNT HILL MAP AREA (2D/5), NEWFOUNDLAND

by

S.P. Colman-Sadd

INTRODUCTION

Mapping of the Burnt Hill area at a scale of 1:50,000 was completed during 1980; parts of it had previously been mapped in 1978 and 1979 (Colman-Sadd 1979, 1980a). The Harbour Breton Highway is located just east of the east edge of the area, which can be reached from the highway, either directly or via Little Gull Lake. A woods road which runs from the Harbour Breton Highway near Bishops Falls, along the southeast side of Great Rattling Brook, provides access to part of the northern edge of the area. The southwest corner can be reached by boat from the Long Pond reservoir via Round Pond, and the southern edge by the road from Bay d'Espoir along the Grand Falls transmission line. Access to the rest of the area is by aircraft; mobility is greatly enhanced by the Northwest Gander River, which in wet weather is navigable from its source to the Harbour Breton Highway.

The area was mapped previously by Anderson and Williams (1970) at the 1:250,000 scale. Grady (1953) mapped the ultramafic rocks north of Burnt Hill for the Newfoundland Government, and these were further investigated by Newfoundland and Labrador Corporation (NALCO) geologists (Harrison, 1953; Gates, 1954; Potter, 1955) and Bell Asbestos Mines Ltd. (1963). McCabe (1955) mapped the ultramafic rocks in the southeast quadrant for NALCO. Wolofsky's map of the Sitdown Pond area (Wolofsky, 1951) showed some of the geology around Through Hill, and Slipp (1952) extended his coverage up to the fault zone west of Newfoundland Dog Pond. Butler and Davenport (1978) did a lake sediment geochemistry study through the whole area.

The Burnt Hill area is divided into two parts by the belt of mafic and ultramafic rocks (Units 1-6, 8) that trends from the northeast to the southwest corner. Southeast of this belt are volcanic and volcanogenic rocks of the Middle Ordovician Baie d'Espoir Group (Units 9-11) (Colman-Sadd, 1976, 1980b). Northwest of the belt are unnamed turbidites (Unit 12) which are more mature than those in the Baie d'Espoir Group and which appear to be lateral equivalents of the Silurian Botwood Group (Anderson and Williams, 1970). These turbidites show progressive metamorphism and anatexis towards two centres in the northwest of the area. At Through Hill, the more southerly of the two, there is an intrusion of pegmatitic garnet-muscovite granite (Unit 13); three similar smaller intrusions occur along the sillimanite isograd around the more northerly centre. These granite bodies are considered to be directly related to the anatexis. A large granite body, the Partridgeberry Hills Granite (Unit 14), has intruded the ultramafic belt, the Baie d'Espoir Group, and the turbidites of Unit 12 posttectonically. It consists mainly of chloritized perthitic granite but also contains some muscovite bearing facies. It contrasts with the granite at Through Hill not only in its mineralogy, but also in its poorly developed metamorphic aureole and its almost complete lack of pegmatites. The youngest rocks in the area are represented by a single exposure of conglomerate (Unit 15) that is dominated by ultramafic clasts; although tilted, these rocks have not been penetratively deformed and are thought to be Devonian molasse sediments.

OPHIOLITIC ROCKS (Units 1-8)

North and northwest of Coy Pond, the belt of mafic and ultramafic rocks widens to reveal a structurally intact ophiolite sequence. Peridotite outcrops

to the west; it is followed eastwards by sheared serpentinite, banded pyroxenite and peridotite, massive pyroxenite, gabbro grading into diabase with sheeted dikes, and mafic pillow lava. Trondhjemite has intruded the diabase, and a thin layer of sedimentary rock overlies the pillow lava.

The peridotite (Unit 1) is a massive, brown weathering, black rock. The only observed internal structure is a local banding of chromite grains. Most of the rock is formed of olivine which in many places is largely serpentinized. Chromite grains are disseminated throughout and prominent orthopyroxene crystals are visible in hand specimen at many of the exposures. A few veins of dunite have intruded the peridotite. No tectonic fabric is visible in hand specimen although the rock is generally cut by irregular fractures, some of which are filled with asbestos. Close to the exposed fault contact at the north end of the outcrop, an anastomosing fracture cleavage has broken the peridotite into pillowlike lenses; tectonically rounded fragments up to 5 m across can be found in the talc schist within the fault zone.

The peridotite is bounded on the east by a narrow continuous band of sheared serpentinite and talc schist (Unit 2). A few peridotite exposures occur on the east side of the band and one banded pyroxenite and peridotite exposure occurs to the west; in general, however, the sheared serpentinite marks the boundary between the two. It weathers a bright orange color and forms a readily mappable horizon not only in the ophiolitic sequence at Coy Pond, but also in those at Great Bend and Pipestone Pond outside the map area (Anderson and Williams, 1970; Williams, 1970). The best asbestos occurrences are associated with the sheared sepentinite.

Banded pyroxenite and peridotite form the western part of Unit 3. The bands are 2 cm to 1 m thick and are defined by variations in composition and pyroxene grain size. Peridotite forms dismembered blocks and intrusive veins as well as conformable bands. Preliminary petrography indicates that the pyroxenite is dominated by clinopyroxene. The proportion of peridotite decreases towards the east so that the eastern part of Unit 3 consists essentially of massive, medium to coarse grained pyroxenite, with only rare veins and xenoliths of peridotite.

Bands of gabbro are present in the central part of Unit 3 and increase in number towards the east, so that the boundary between the dominantly ultramafic rocks of Unit 3 and the gabbro of Unit 4 is irregular and in places gradational. The gabbro is medium to coarse grained in the west, where it contains xenoliths of pyroxenite and is cut by rare gabbro pegmatite veins. It becomes progressively finer grained towards the east, passing imperceptibly into diabase. The gabbro is generally massive; banding was found in only one location, and then in a loose boulder. In many outcrops, the rock is altered and brecciated; a tectonic fabric is present locally. In the eastern part of Unit 4, where the rock is diabase, most exposures are small and structureless. Sheeted dikes were seen in only one exposure, where dike width varies from 10 cm to 1 m; the dike boundaries show evidence of shearing and no chilled margins were identified.

An intrusion of trondhjemite (Unit 5) is present within the outcrop area of Unit 4 and is itself intruded by diabase dikes. Many of its contacts, where it has intruded gabbro and diabase, are gradational zones of silicified mafic rock. The contacts with the dikes that intruded the trondhjemite, however, are sharp, although the dikes have in most cases been affected by the strong foliation in the trondhjemite, and are sheared or boudinaged. This foliation is poorly developed in the surrounding gabbroic rocks of Unit 4.

LEGEND

DEVONIAN (?) OR LATER

15 Fluviatile conglomerate formed of ultramafic clasts

SILURIAN ?

14 **Partridgeberry Hills Granite: 14a,** Chloritized biotite-perthite granite; **14b,** muscovite granite.

13 Muscovite granite.

12 **Botwood Group equivalents?:** Interbedded sandstone and semipelite forming turbidite cycles; gs, greenschist facies; a, with andalusite porphyroblasts; s, with probable sillimanite porphyroblasts; m, migmatitic; bg, banded granitoid gneiss; ug, unbanded granitoid rock.

ORDOVICIAN

BAIE D'ESPOIR GROUP (NORTH STEADY POND FORMATION)

11 Felsic and intermediate volcanic rocks, mainly pyroclastic but including some flows.

10 Conglomerate, probably resedimented.

9 Volcanogenic sandstone and semipelite forming tubidite cycles.

MIDDLE ORDOVICIAN OR EARLIER

8 Brecciated and sheared serpentinite, mainly derived from Unit 3.

7 Thinly bedded black argillite and sandstone.

6 Mafic pillow lava.

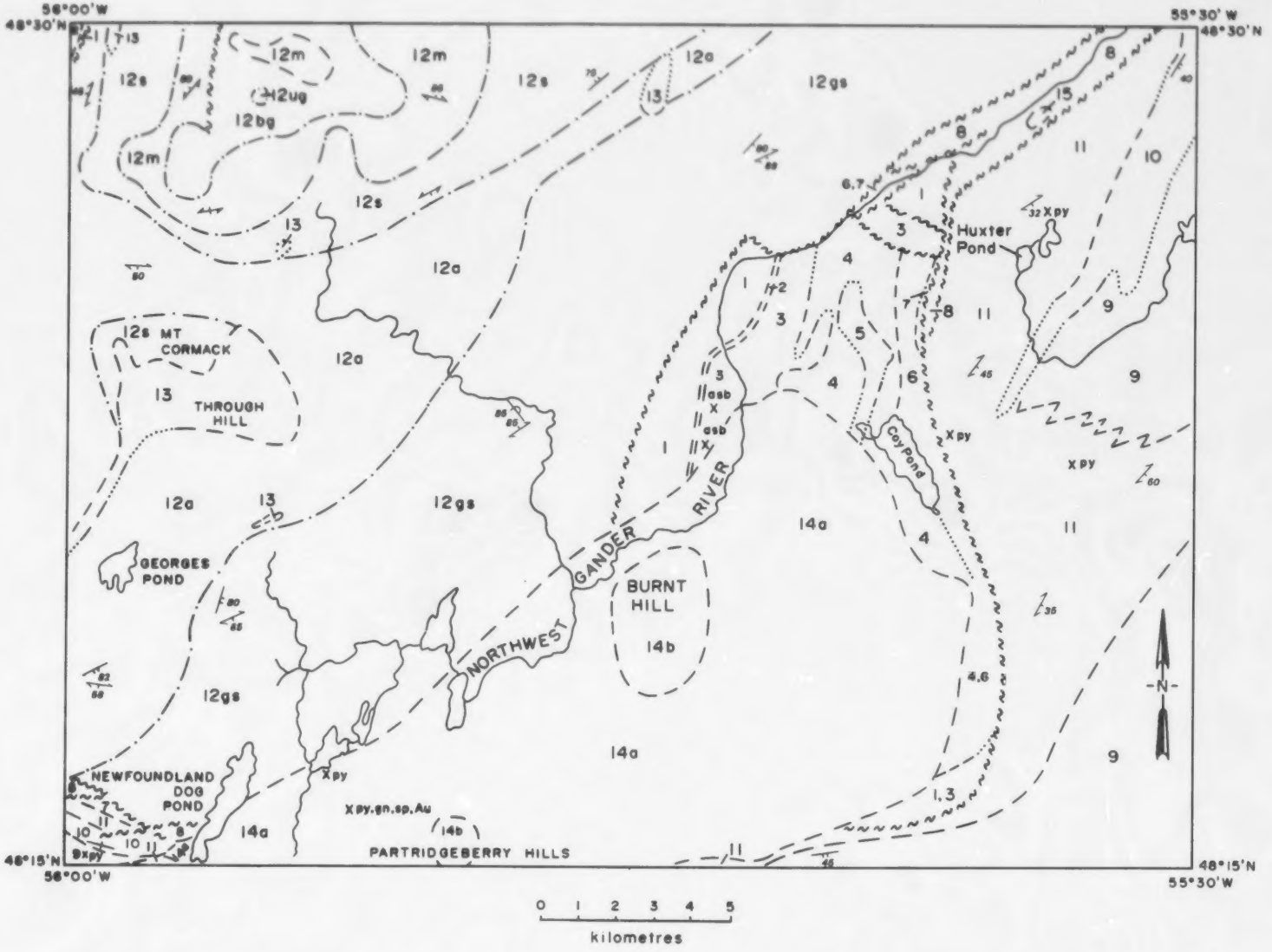
5 Trondhjemite.

4 Gabbro and diabase.

3 Pyroxenite, and banded pyroxenite and peridotite.

2 Sheared serpentinite.

1 Peridotite.


56°00'W
48°30'N
55°30'W
48°30'N
12m
12s
12bg
12ug
12a
12gs
MT CORMACK
THROUGH HILL
GEORGES POND
NEWFOUNDLAND DOG POND
Huxter Pond
Coy Pond
GANDER RIVER
NORTHWEST
BURNT HILL
14a
14b
PARTRIDGEBERRY HILLS
Xpy
Xpy,gn,sp,Au
gsb
N
0 1 2 3 4 5
kilometres
48°15'N
56°00'W
48°15'N
55°30'W

The boundary between the diabase of Unit 4 and mafic pillow lava of Unit 6 is fairly sharp and easily mapped north of Coy Pond. The pillow lava has variolitic texture and is extensively epidotized. In the fault block exposed along the Northwest Gander River, pillow lava grades into pillow breccia.

North of Coy Pond, pillow lava is overlain with apparent conformity by Unit 7. At the base of the unit is black argillite with 1 mm to 1 cm thick siltstone and sandstone beds. The beds are commonly channelled and have load casts, and parallel and cross laminations. They are overlain by poorly sorted conglomerate, which is also well exposed in a fault block on the Northwest Gander River, where it sits directly on pillow lava. The clasts in the conglomerate are angular to subrounded and principally of mafic volcanic composition. Clasts of felsic volcanic and plutonic rocks are also common and quartz grains occur in the matrix.

The western edge of the ophiolite sequence is unexposed but is presumed to be faulted against sedimentary rocks of Unit 12. Peridotite close to the assumed fault is more fractured than elsewhere. The fault that cuts across the strike of the sequence at its northern end is exposed in a cliff beside the Northwest Gander River; black argillite and sandstone of Unit 12 overlie a breccia of serpentinized peridotite in a talc schist matrix. Farther east, just south of the river, the same fault zone is exposed with gabbro overlying the talc schist. The fault is assumed to continue northeastwards down the valley of the Northwest Gander River to the Great Bend ultramafic complex in the Miguels Lake map area (2D/12) (Kean, 1974); preliminary observations show that this complex contains the same three ultramafic units (1-3) as the sequence at Coy Pond. The protolith of the serpentinite schist and breccia (Unit 8) in this northeasterly part of the fault zone appears to have been banded pyroxenite and peridotite of Unit 3. A similar protolith is indicated for the serpentinite breccia that marks the fault zone along the east side of the ophiolite sequence, separating sediments of Unit 7 from felsic volcanic rocks of Unit 11.

The ophiolite sequence at Coy Pond was intruded by the Partridgeberry Hills Granite and good exposures of the intrusive contact are exposed just east of the Northwest Gander River. Units 4 and 6 can be traced southwards along the edge of the granite pluton, but poor exposure and disruption by the pluton make it difficult to separate diabase from pillow lava. Banded pyroxenite and peridotite of Unit 3, and peridotite of Unit 1 reappear at the southeast corner of the granite; they are presumed to have been contiguous with the ultramafic rocks to the north before the granite was intruded.

The ultramafic belt continues at the southwest end of the Partridgeberry Hills Granite as a series of blocks in the fault zone west of Newfoundland Dog Pond. This zone continues northwestwards to connect with the north trending Pipestone Pond ultramafic complex (Slipp, 1952). Part of this complex outcrops in the northwest corner of the map area, where peridotite with a west dipping fracture cleavage has been thrust over sediments of Unit 12. The ultramafic units (1, 2 and 3) defined in the ophiolite at Coy Pond were also observed in the Pipestone Pond complex, but with opposite polarity. They pass westwards into gabbro, diabase and pillow lava (Wolofsky, 1951; Kean, 1974).

BAIE D'ESPOIR GROUP (Units 9-11)

Within the Burnt Hill map area, the Baie d'Espoir Group is represented by rocks presently assigned to the North Steady Pond Formation (Colman-Sadd, 1980b). It is possible that the volcanic rocks will be separated at a later date when presumed on-strike equivalents have

been mapped near Great Burnt Lake. Three units are recognized in this report; sandstone and phyllite (Unit 9), conglomerate (Unit 10) and volcanic rocks (Unit 11). The relative stratigraphic positions of these units are unknown.

The dominant rock type of Unit 9 is volcanogenic, arkosic sandstone. It is medium to fine grained and beds are commonly graded; bed thickness is generally 10 to 60 cm, although locally beds are less than 5 cm thick. The sandstone is interbedded with green-gray phyllite containing siltstone laminations.

Conglomerate of Unit 10 is well exposed on Little Gull River in the northeast corner of the map area, and in the brook flowing out of Newfoundland Dog Pond in the southwest corner. In between, the mapping of this unit is based on limited exposure and boulder distributions. The clasts in the conglomerate are argillite, siltstone, psammite, fine to medium grained felsic and mafic igneous rocks, chert, calcite, feldspar and vein quartz. They vary in size from 0.02 mm to 15 cm, are subangular to rounded, and are set in a mudstone matrix. Near Newfoundland Dog Pond, the conglomerate beds are 30 cm to 1 m thick and are interbedded with coarse sandstone; bed contacts are gradational. In the northeast corner of the area, the conglomerate beds are much thicker (10 m or more); they are associated with black argillite and volcanogenic sandstone beds similar to those found in Unit 9.

Unit 11 consists of a variety of felsic and intermediate volcanic rocks. The dominant lithology is felsic crystal tuff with a fine grained matrix and crystals of quartz and feldspar up to 3 mm across. Probable rhyolite flows with quartz and feldspar phenocrysts have been found southwest of Newfoundland Dog Pond, and west of Huxter Pond adjacent to the faulted contact with serpentinite. Fine grained intermediate volcanic rocks which probably include both flows and pyroclastics occur due east of Coy Pond. Zones of sericitic alteration and pyrite mineralization have been found at several localities in Unit 11 and are indicated on the map; no other sulphide minerals were observed, although assays of samples have given slightly anomalous values of base metals and silver (Colman-Sadd, 1980a).

The rocks of the Baie d'Espoir Group within the map area were regionally metamorphosed in the greenschist facies. They have been deformed twice. The first deformation formed tight to isoclinal folds and a foliation that is generally subparallel to bedding. The second deformation is most obvious near the contact with the Partridgeberry Hills Granite at the southern edge of the area. It formed open to close recumbent folds and a nearly horizontal crenulation cleavage.

SANDSTONE AND SHALE (Unit 12)

Unit 12 occupies the northwest half of the map area. It is similar in rock type to units containing Silurian fossils farther east (Anderson and Williams, 1970), but there is not yet sufficient detailed map coverage to make a definite correlation. The unit is therefore only tentatively assigned to the Silurian.

Good exposures, displaying the original sedimentary character of the unit, are present in the southeast flowing tributaries of the Northwest Gander River. Sandstone beds, 10 cm to several metres thick, are interbedded with shale beds varying from 1 cm to 1 m thick. The sandstone is medium to fine grained and rich in quartz; graded bedding, load structures, and ripple-drift lamination are common, suggesting rapid deposition by turbidity currents. The shale beds contain numerous siltstone laminations and are commonly channeled by sandstone beds.

Unit 12 shows progressive low pressure regional metamorphism towards two centres in the western part of the map area. The andalusite and sillimanite isograds shown on the map are drawn where porphyroblasts of these minerals become clearly visible in the field. Future microscopy may require them to be redrawn. In the migmatitic zone (12m), the shale beds with their siltstone laminations show evidence of having melted to form a granitoid liquid, but the sandstone beds have remained intact. In the banded gneiss zone (12 bg), sandstone beds are represented by a few disjointed slabs, but generally the sedimentary features of the rock have been destroyed. The gneiss itself is of semipelitic composition with biotite-rich and quartzofeldspathic layers interbanded on a 1 mm to 1 cm scale; garnet is a common accessory mineral. In one location the banding has gradually faded out and the gneiss has become massive (12 ug). Other than the presence of a few amphibolite blocks in the banded gneisses, there is no evidence to suggest that any rocks other than those belonging to Unit 12 have been involved in the metamorphism.

Metamorphism of Unit 12 near the Partridgeberry Hills Granite is quite different in character from the regional metamorphism to the northwest. A very narrow aureole, which probably nowhere exceeds 100 m in width, has been formed. Within the aureole, the sediments have been metamorphosed to hornfels and spotty slate.

The rocks of Unit 12 have been tightly folded around axes that plunge vertically or steeply to the southwest. A well developed axial planar cleavage strikes southwest and, in general, is nearly vertical. These structures represent the main deformation. An earlier deformation is indicated by reversed facing directions of bedding on the main cleavage, and by an early cleavage which is only really apparent near the ultramafic belt. In parts of the migmatitic and gneissic zones, a later deformation has formed tight folds and has transposed bedding and the main cleavage to form a gneissic banding. The north trending fault along the western margin of the banded gneiss is marked by mylonite.

MUSCOVITE GRANITE (Unit 13)

Five granitic bodies are included in Unit 13. All except the one east of Georges Pond are pegmatitic muscovite granite with prominent garnet and tourmaline crystals. The small granite body east of Georges Pond is medium grained and no garnet or tourmaline have been recognized in it. Biotite occurs in the intrusions where the country rocks have been assimilated.

The granites are undeformed and the one at Through Hill truncates large scale folds formed during the main deformatin of Unit 12 (Colman-Sadd, 1980a). This granite also truncates the sillimanite isograd, indicating that the metamorphism was not caused directly by the granite.

The location of the granite bodies, in each case close to the sillimanite isograd, implies a relationship between granite origin and metamorphism. It is suggested that the granites represent the melt fraction from the sediments of Unit 12, and that the banded and unbanded gneisses (12bg, 12ug) are the residue. The granites are located along the sillimanite isograd because this formed at pressure and temperature conditions corresponding to the solidus of the melt. The granites and the metamorphism are, therefore, the results of the same heat sources, but are not in themselves cause and effect. The Through Hill metamorphic centre is regarded as less deeply eroded than the centre to the north. In the former case, erosion has reached the apex of the sillimanite isograd and corresponding granite solidus, so that these occupy the middle of the outcrop. In the latter case, erosion has cut deeper and exposed the high temperature gneissic rocks around

which the sillimanite isograd and granite solidus form a perimeter.

The granite at Through Hill has been dated by the Rb/Sr method at 432±5 Ma (initial ratio 0.721) by P.Elias (personal communication).

PARTRIDGEBERRY HILLS GRANITE (Unit 14)

This granite forms a large intrusion, elongated in a west-southwest direction parallel to the regional structural trend. The main part of the granite (14a) is medium to coarse grained, gray or pink, locally vuggy, and pervasively altered. The feldspars are plagioclase (An_{33}) and perthitic microcline, the latter indicating a high level of intrusion. The mica is biotite which has been partially or completely altered to chlorite.

At two localities, a separate muscovite-rich facies (14b) is developed. This rock is fine to medium grained, and equigranular. Analyses show that it is distinctly richer in silica than the biotite granite. The contact relationships between the two granites are unknown.

Pegmatite and aplite veins are very scarce in both facies of the granite, but quartz veins are common. Two particularly large quartz veins cut the southwestern end of the granite and are responsible for the two mineral occurrences shown in that part of the map area. Assays from these veins were reported by Colman-Sadd (1980a).

Most of the Partridgeberry Hills Granite is undeformed. In the southeastern part of the intrusion, a fairly well defined fabric has been attributed to partial assimilation of previously foliated metasedimentary rocks (Colman-Sadd, 1980b). There are, however, parts of the granite, notably the muscovite bearing facies in the southwest, that clearly have been deformed and have a cataclastic fabric.

DEVONIAN(?) CONGLOMERATE (Unit 15)

The conglomerate is exposed at one locality in the Northwest Gander River valley. It is presumed to overlie unconformably sheared serpentinite of Unit 8, but this relationship is uncertain because of poor exposure.

The clasts consist mainly of brown weathering peridotite (Unit 1) and orange weathering, sheared serpentinite (Units 2 and 8). There are also some clasts of gabbro, mafic and felsic volcanic rock, and argillite. Grain size varies from 0.2 mm to over 30 cm; there is no clay or silt fraction and the rock is clast supported. Clasts are subangular to subrounded. Sorting is poor, except in a few sandstone lenses which may be up to 10 cm thick.

The conglomerate dips 50° to the east, but otherwise shows no evidence of deformation. In particular, it contrasts with conglomerate of Unit 10 in that it has no foliation. Individual clasts, and particularly serpentinite clasts, were deformed prior to deposition.

The age of the conglomerate is thought to be Devonian because it apparently postdates Acadian deformation and emplacement of the ultramafic belt (Colman-Sadd, in press). No distinction has been made between possible fluviatile or turbidite modes of sedimentation. However, given the probable tectonic environment in the Devonian, it is considered that fluviatile deposition is more likely.

MINERALIZATION

The most obvious potential for mineral deposits in the Burnt Hill area lies in the felsic and intermediate volcanic rocks (Unit 11) of the North Steady Pond Formation. These rocks are on strike with and probably laterally equivalent to the mineralized Great Burnt Lake volcanic belt. They are

interpreted as forming the southeastern flank of the pre-Caradocian island arc of Dean (1977). Four occurrences of disseminated pyrite in these rocks are shown on the map.

The mafic pillow lavas (Unit 6) and diabase dikes (Unit 4) at the top of the Coy Pond ophiolitic sequence contain ubiquitous, but minor, amounts of disseminated pyrite. Their geologic association suggests the possibility of economic concentrations of sulphide minerals to form Cyprus-type deposits.

The mineral potential of the ultramafic part of the Coy Pond sequence (Units 1 to 3), the muscovite granites (Unit 13), and the Partridgeberry Hills Granite (Unit 14) was discussed by Colman-Sadd (1980a). It is considered to be less than that of the volcanic rocks.

ACKNOWLEDGEMENTS

Anthony Benoit is thanked for able assistance in the field. The manuscript was reviewed by Frank Blackwood and Baxter Kean. The date on the granite at Through Hill was determined by Peter Elias at Memorial University of Newfoundland.

REFERENCES

Anderson, F.D., and Williams, H.
1970: Gander Lake (west half), Newfoundland. Geological Survey of Canada, Map 1195A.

Bell Asbestos Mines Ltd.
1963: Diamond drilling data, Northwest Gander River, Newfoundland. Unpublished company report.

Butler, A.J., and Davenport, P.H.
1978: A lake sediment geochemical survey of the Meelpaeg Lake area, central Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Open File Newfoundland 986, 36 pages.

Colman-Sadd, S.P.
1976: Geology of the St. Alban's map-area, Newfoundland (1M/13). Newfoundland Department of Mines and Energy, Mineral Development Division, Report 76-4, 19 pages.

1979: Geology of Twillick Brook (2D/4) and part of Burnt Hill (2D/5), Newfoundland. *In* Report of Activities for 1978. *Edited by* R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 79-1, pages 30-34.

1980a: Geology of parts of the Burnt Hill map area (2D/5), Newfoundland. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Dapartment of Mines and Energy, Mineral Development Division, Report 80-1, pages 44-49.

1980b: Geology of the Twillick Brook map area (2D/4), Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 79-2, 23 pages.

In press: Geology of south-central Newfoundland and evolution of the eastern margin of Iapetus. American Journal of Science.

Dean, P.L.
1977: A report on the geology and metallogeny of the Notre Dame Bay area, to accompany metallogenic maps 12H/1, 8, 9, and 2E/3, 4, 5, 6, 7, 9, 10, 11 and 12. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 77-10, 17 pages.

Gates, W.G.
1954: Great Gull Lake - Coy Pond area, central Newfoundland. NALCO unpublished company report, 4 pages.

Grady, J.C.
1953: The geology of the southern half of the serpentine belt in east-central Newfoundland. Geological Survey of Newfoundland, unpublished report, 63 pages.

Harrison, W.D.
1953: The Northwest Gander River area. NALCO unpublished company report, 3 pages.

Kean, B.F.
1974: Notes on the geology of the Great Bend and Pipestone Pond ultramafic bodies. *In* Report of Activities 1973. *Edited by* W.R. Smyth. Newfoundland Department of Mines and Energy, Mineral Development Division, pages 33-42.

McCabe, H.B.
1955: Baker Lake area, central Newfoundland. NALCO unpublished company report, 3 pages.

Potter, R.R.
1955: Summary report, Burnt Hill area. NALCO unpublished company report, 11 pages.

Slipp, R.M.
1952: The geology of the Round Pond map-area, Newfoundland. M.Sc. thesis, McGill University, Montreal, 81 pages.

Williams, H.
1970: Red Indian Lake (east half), Newfoundland. Geological Survey of Canada, Map 1196A.

Wolofsky. L.
1951: Geology of the Sitdown Pond area, central Newfoundland. M.Sc. thesis, McGill University, Montreal, 47 pages.

GEOLOGY OF THE WEST GANDER RIVERS AREA, NEWFOUNDLAND

by

R. Frank Blackwood

INTRODUCTION

The east half of the West Gander Rivers (2D/11) map area and the northwest corner of the Dead Wolf Pond (2D/10) map area were mapped on a 1:50,000 scale during the 1980 field season. Rocks of this area are continuous northeastward and along strike with those of the Gander map area, 2D/15 (Blackwood, 1980) and the Gander River map area, 2E/2 (Blackwood, 1979a). The area forms part of the Gander Rivers Project, initiated in 1978 to map The Gander River Ultrabasic Belt and adjacent rocks from the mouth of Gander River in the northeast to Great Gull Lake in the southwest.

Access is provided by excellent wood roads, operated by Bowater Newfoundland Limited, along the Northwest Gander River and from there to the Southwest Gander River in the vicinity of Paul's Pond. Old, locally impassable, Bowater roads are located in the Dead Wolf Brook - Caribou Lake area. Mapping in the southern half of the map area was carried out by fly camp and helicopter traverses.

Bedrock exposure is nearly continuous along the northern part of the Southwest Gander River; it is also good along parts of Dead Wolf Brook. However, apart from well exposed areas along a ridge south and northeast of Caribou Lake (underlain by the GRUB line), there is very limited outcrop in the rest of the map area.

The northwest corner of the Dead Wolf Pond (2D/10) area formed part of a larger mapping project by the Geological Survey of Canada (Jenness, 1963). Part of the Middle Ridge Granite and its associated metamorphic aureole were outlined.

The West Gander Rivers (2D/11) area was also included in a Geological Survey of Canada study (Anderson and Williams, 1970). Their mapping defined part of the Mount Peyton Intrusive Suite, fossiliferous Silurian country rocks, and the Middle Ridge Granite.

GENERAL GEOLOGY

The area comprises four tectonostratigraphic subdivisions: the Gander Group (1-2), the Gander River Ultrabasic Belt (3-4), the Davidsville Group (5-7), and the Botwood Group (8). The Gander Group is intruded by the Middle Ridge Granite (9) and the Botwood Group by the Mount Peyton Intrusive Suite (10).

Gander Group (Unit 1-2)

The Gander Group (McGonigal, 1973) forms a southwest-northeast trending belt (like all other units in this area) which underlies the eastern part of the map area. A small area of Unit 1 occurs in the extreme northeastern corner of the map area; it forms part of the larger subdivision of the Gander Group that extends to the northeast. Psammite, semipelite and minor pelite constitute Unit 1. A strong foliation overprints these rocks and is defined by a fine to coarse grained schistosity in the more pelitic compositions. The micas are mimitically recrystallized along a preexisting fabric; low to middle amphibolite facies metamorphism, spatially related to the Middle Ridge Granite, is relatively late synkinematic to posttectonic.

Unit 2 is more pelitic in overall composition than Unit 1, with semipelite predominating. However, psammite beds are common in Unit 2 and minor 5 to 20 cm thick quartzite beds occur where it crosses the Southwest Gander River.

Units 1 and 2 are separated by a conformable contact to the northeast (Blackwood, 1980), with the main distinction between the two being the presence of narrow, concordant, amphibolite bands in Unit 2. These bands are apparently conformable with the enclosing metasediments and are interpreted to represent mafic volcaniclastics. The main fabric in Unit 2 is a fine to coarse grained schistosity that is axial planar to small scale, variably plunging, isoclinal folds. Locally, a pronounced strain-slip cleavage overprints the main fabric. The low to middle amphibolite facies metamorphism is demonstrably related to the Middle Ridge Granite, increasing with proximity to the intrusion. Andalusite, cordierite, biotite, garnet, hornblende, and staurolite commonly form posttectonic porphyroblasts.

Gander River Ultrabasic Belt (Units 3 and 4)

The Gander River Ultrabasic Belt (Jenness, 1958), informally referred to as the GRUB line (Blackwood, 1979b), outcrops along two narrow, discontinuous zones northeast and south of Caribou Lake. The GRUB line is interpreted to be in fault contact with the Gander Group (Blackwood, 1979b).

Ultrmafics and their alteration products (Unit 3) mainly define the GRUB line. The zone northeast of Caribou Lake contains fine to coarse grained gabbro and hornblende which are locally banded; the strike of the banding is at a high angle to the regional structural trend. Small areas of serpentinite, magnesite, and amphibolite also occur. In the same zone, southwest of Dead Wolf Brook, a small ultramafic sliver that was originally pyroxenite is mostly altered to tremolite and minor magnesite. Unit 3 south of Caribou Lake contains minor unaltered dunite with tremolite - talc - magnesite schist and serpentinite predominating.

A narrow belt of amphibolite and volcanic rocks (Unit 4) is adjacent to and west of Unit 3 in the zone northeast of Caribou Lake. It is included in the GRUB line although the exact relationship between Units 3 and 4 is unknown. Most of this unit is underlain by amphibolite; a 0.5 to 1.5 cm banding is preserved and interpreted as a primary structure. The amphibolite varies from fine to coarse grained and probably represents mafic volcaniclastics or flows. White, quartz and quartz-feldspar porphyry bands (50 cm to 4 m wide) are interlayered with the amphibolite. The quartz phenocrysts are generally clear and occur in a fine grained felsic matrix. Conglomerate bands, 1-10 m wide, are locally interbedded with the volcanic rocks. Clasts range from 2 mm to 8 cm in diameter and consist mostly of quartz and quartz porphyry in a felsic to mafic matrix; a distinctive blue hue generally marks the quartz. Other bands consist entirely of strongly flattened, recrystallized, fine grained, felsic clasts. These clastic rocks are interpreted as volcanic conglomerates.

The GRUB line is overprinted by the main regional foliation. It is best developed in altered portions of the ultramafic rocks (Unit 3). Intense flattening is generally associated with fabric development in the volcanic rocks of Unit 4. Units 3 and 4 are overprinted by the same amphibolite facies hornfelsing as Units 1 and 2. Hornblende crystals are disoriented, the felsic volcanics are granoblastic and oriented minerals are mimetic. Locally, due east of the juncture of Dead Wolf Brook and Southwest Gander River, Unit 3 contains elongate olivine, disposed in a radiating, criss-crossing pattern. Crystals are 1-2 cm long and 1-2 mm wide with commonly tiangular shaped interstitial material. Nearly all the olivine is pseudomorphed by antigorite and the insterstitial material is also altered to antigorite. The "spinifex-like" texture is interpreted to be metamorphic in origin (Evans and Trommsdorff, 1974), related to the intrusion of the Middle Ridge Granite (Unit 9).

LEGEND

DEVONIAN OR OLDER

MOUNT PEYTON INTRUSIVE SUITE

10 *Fine to medium grained pink granite*

MIDDLE RIDGE GRANITE

9 *Medium grained, two-mica, garnetiferous, leucogranite*

SILURIAN

BOTWOOD GROUP

8 *Fine to coarse grained, light gray sandstone, siltstone, and shale; minor red shale and sandstone; minor fossiliferous calcareous beds*

MIDDLE ORDOVICIAN AND LATER

DAVIDSVILLE GROUP

7 *Fine to coarse grained dark graywacke, commonly with shale intraclasts, interbedded with gray to black siltstone and shale; minor conglomerate lenses*

6 *Gray to black shale with thin siltstone beds, locally graphitic; minor fine to medium grained graywacke beds*

5 *Fine to coarse grained conglomerate with predominantly quartz-porphyry clasts (quartz phenocrysts commonly have a bluish hue)*

MIDDLE ORDOVICIAN OR EARLIER

GANDER RIVER ULTRABASIC BELT (GRUB)

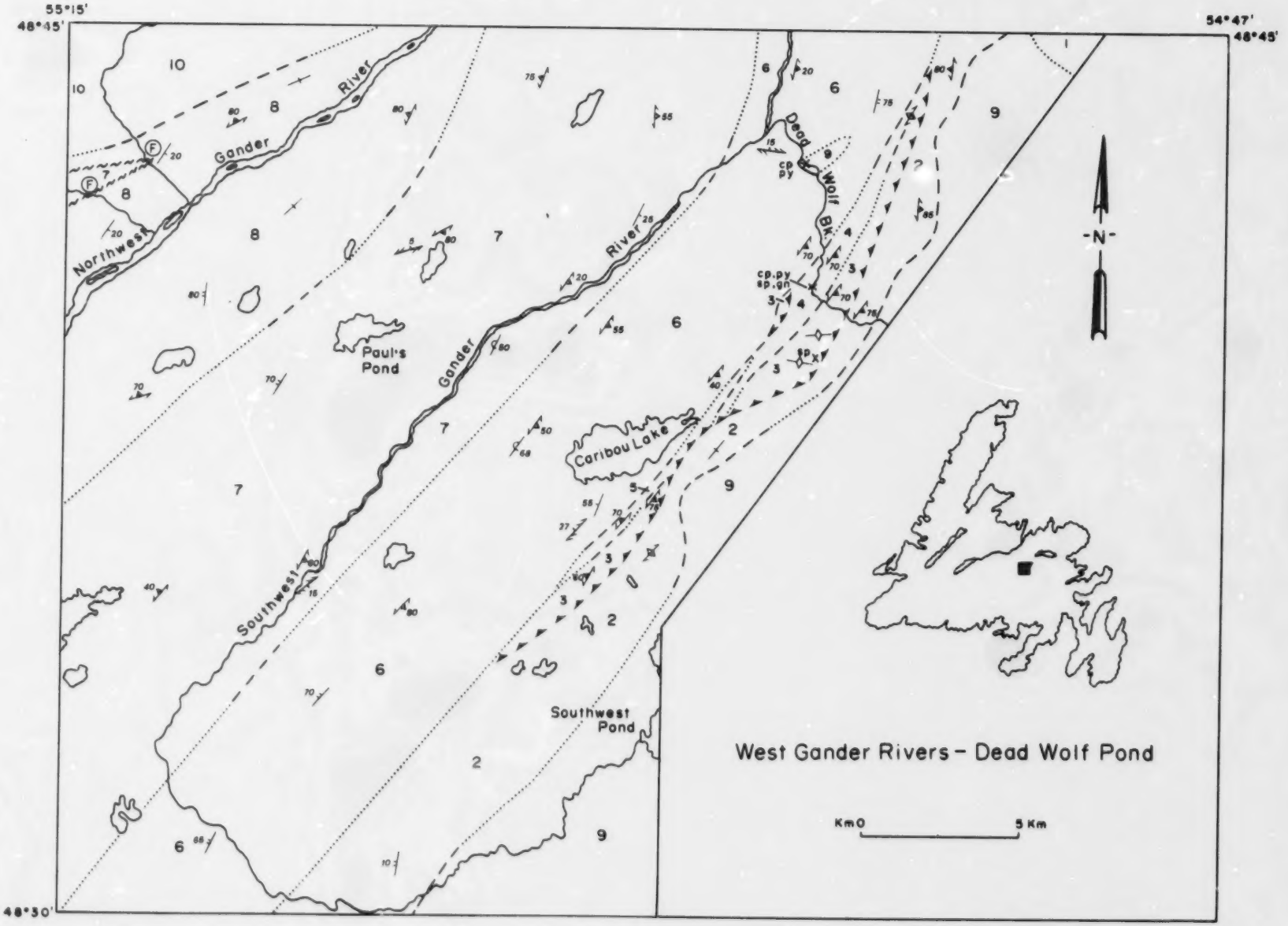
4 *Amphibolite, mafic to intermediate volcaniclastic rocks, and quartz porphyritic felsic volcanics*

3 *Serpentinite and gabbro with minor hornblendite, magnesite, amphibolite (tremolite and hornblende) and talc schist.*

GANDER GROUP

2 *Semipelite, pelite, minor psammite, quartzite, and concordant amphibolite bands*

1 *Psammite and semipelite*


55°15'
48°45'
54°47'
48°45'
48°30'
Gander River
Northwest
Paul's Pond
Gander River
Dead Wolf Bk.
Caribou Lake
Southwest
Southwest Pond
-N-
West Gander Rivers – Dead Wolf Pond
Km 0
5 Km

Davidsville Group (Units 5-7)

The Davidsville Group (Kennedy and McGonigal, 1972) underlies the central part of the map area and is subdivided into three lithological units. Its relationship to the GRUB line is unclear; a nonconformity separates the two elsewhere (Blackwood, 1980) and a similar, perhaps fault modified, contact probably forms the boundary in this region. The Davidsville Group is interpreted to conformably overlie the Gander Group; locally, the contact may be faulted in association with GRUB emplacement.

The base of the Davidsville Group is marked by a fine to coarse grained conglomerate (Unit 5) that forms a narrow belt east of Caribou Lake. It is coarsest in its southern part and adjacent to the GRUB line. The clasts consist almost entirely of quartz porphyry and range from 0.5 to 30 cm in diameter. Mafic patches in the matrix may indicate ultramafic, gabbroic or basaltic debris. The porphyry clasts are similar to those in the volcanic conglomerate beds of Unit 4; the quartz porphyry bands in Unit 4 are a probable source for both occurrences of conglomerate.

The conglomerate of Unit 5 appears to grade abruptly westward into gray and grayish black shale and siltstone (Unit 6) . The shales are locally graphitic and laminated; siltstone beds are 2 to 12 cm thick and have sharp boundaries. Fine to coarse grained graywacke beds form a minor component of Unit 6 and generally occur near the boundary with Unit 7.

The top of the Davidsville Group is mainly marked by fine to coarse grained graywacke with minor shale interbeds (Unit 7). Graywacke beds vary from 5 to 60 cm in thickness with sharp, coarse bases. The finer grained tops are generally laminated and grade into laminated (2 to 6 mm thick) siltstone and shale. Minor, poorly sorted conglomerate lenses commonly contain shale intraclasts. Grayish black shale (phyllite on the southwest Gander River, east of Paul's Pond) and minor gray siltstone, without any graywacke beds, occur as zones within the unit. A faulted sliver of graphitic black shales occurs within the Silurian Botwood Group, north of the Northwest Gander River. A poor collection from a new fossil locality contained the following graptolites: *Climacograptus bicornis* (Hall) or *spiniferus* Ruedemann, *Hailograptus?*, *Orthograptus?*, and a stipe of *Dicellograptus*, indicating an early or late Caradocian age (John Riva, written communication, 1980).

The Davidsville Group is overprinted by a pronounced slaty cleavage which becomes phyllitic to schistose with proximity to the Middle Ridge Granite. The main fabric is axial planar to recumbent, tight to isoclinal folds, that are overturned to the northwest in the Southwest Gander River and Caribou Lake areas. A widely spaced, strain-slip fabric transposes the main foliation and is best developed in outcrops of shale and siltstone. The metamorphic grade varies from low greenschist in the Paul's Pond area to high greenschist, low amphibolite facies in the Caribou Lake area. In the latter area, the fabric is defined by mimetically crystallized muscovite and biotite; biotite, garnet and andalusite also occur as porphyroblasts.

Botwood Group (Unit 8)

The Botwood Group (Williams, 1962) outcrops in the northwestern part of the map area on either side of the Northwest Gander River; its contact with the Davidsville Group is not exposed but the two are presumed conformable. The group comprises fine to coarse grained sandstone, locally containing detrital mica, interbedded with siltstone and shale (Unit 8). The sandstones are generally graded and thickly bedded with 2 to 4 mm laminations; crossbedding occurs locally. These rocks are light gray or reddish brown in color with gray predominating; most of the red beds occur on the north side of the Northwest Gander River. Fine grained, mostly red, minor conglomerate beds occur locally with the sandstone.

Minor fossiliferous limestone and calcareous sandstone are interbedded with these rocks; fossils include coral, crinoid stems, and brachiopods dated as Silurian (Anderson and Williams, 1970).

A slaty cleavage overprints the Botwood Group. It is concordant with the main regional fabric in the Davidsville Group and is locally folded about moderately tight, small scale, folds.

Middle Ridge Granite (Unit 9)

The Middle Ridge Granite (Strong *et al.*, 1974) underlies the eastern boundary area of the map area. The main body of the granite intrudes Units 1 and 2 of the Gander Group; a small granite body of similar composition intrudes Unit 6 of the Davidsville Group on Dead Wolf Brook and is interpreted as an apophysis of the Middle Ridge Granite. The pluton is a fine to medium grained, approximately equigranular, two-mica, leucocratic granite (Unit 9). Small, red garnets are common in the quartz-feldspar-muscovite and/or biotite assemblage; garnets were not noted in the small plug on Dead Wolf Brook. A whole-rock Rb-Sr isochron age of 370±15 Ma has been obtained for the Middle Ridge Granite (Bell *et al.*, 1977).

The Middle Ridge Granite is generally unfoliated in this area. However, a weak mica alignment occurs locally in the contact area. The metamorphism related to the Middle Ridge Granite has resulted in porphyroblasts that mostly overprint structures in the country rocks; rarely, some porphyroblasts define weak augen.

Mount Peyton Intrusive Suite (Unit 10)

A pink, medium grained, equigranulr granite (Unit 10) occurs in the extreme northwestern part of the map area and forms part of the Mount Peyton Intrusive Suite (This name is informallly used here for the Mount Peyton batholith of Strong, 1979). Pink feldspar is generally more abundant than quartz; minor white feldspar and chlorite occur locally. The granite is unfoliated and gives a whole-rock Rb-Sr isochron age of 380±30 Ma (Bell *et al.*, 1977).

MINERALIZATION

Pyrite and chalcopyrite occur in a 1 m wide shear zone in the small granite plug (Unit 9) on Dead Wolf Brook. NALCO reported pyrite, chalcopyrite, sphalerite and minor galena in volcanic rocks (Unit 4) on the same brook (Potter, 1955). The mineralization is disseminated in a 30 cm wide felsic host and also occurs as small pods and stringers. Minor sphalerite occurs in quartz, associated with an aplite dike that cuts ultramafic rocks (Unit 3) south of Dead Wolf Brook.

Note: An arsenopyrite showing occurs in sheared gabbro (previously interpreted as a fine grained volcanogenic rock) of the Gander River Ultrabasic Belt north of Gander Lake (Blackwood, 1979a). A sample from the showing, located northeast of Jonathans First Pond in the Gander River (2E/2) map area (Blackwood, 1979b), assayed 6 g/t gold.

ACKNOWLEDGEMENTS

Lewis Wheaton is thanked for providing excellent field assistance. Also a thank-you to Jim Fenton and Jim Clark of Hudson's Bay Oil and Gas Limited for useful discussion and the helicopter tour. Bowater Newfoundland Limited readily cooperated in permitting use of company roads. B. F. Kean and S. P. Colman-Sadd critically read the manuscript.

REFERENCES

Anderson, F.D. and Williams, H.
1970: Gander Lake (west half), Newfoundland. Geological Survey of Canada, Map 1195A (geological map and descriptive notes.)

Bell, K. Blenkinsop, J. and Strong, D.F.

1977: The geochronology of some granitic bodies from eastern Newfoundland and its bearing on Appalachian evolution. Canadian Journal of Earth Sciences, volume 14, pages 456-476.

Blackwood, R.F.

1979a: Geology of the Gander River area (2E/2), Newfoundland. *In* Report of Activities for 1978. *Edited by* R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 79-1, pages 38-42.

1979b: Gander River, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Divison, Map 7929 (geological map and descriptive notes).

1980: Geology of the Gander (west) area (2D/15), Newfoundland. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 53-61.

Evans, B.W. and Trommsdorff, V.

1974: On elongate olivine of metamorphic origin, Geology, volume 2, pages 131-132.

Jenness, S.E.

1958: Geology of the Gander River Ultrabasic Belt, Newfoundland. Geological Survey of Newfoundland, Report 11, 58 pages.

1963: Terra Nova and Bonavista map areas, Newfoundland. Geological Survey of Canada, Memoir 327, 184 pages.

Kennedy, M.J. and McGonigal, M.H.

1972: The Gander Lake and Davidsville Groups of northeastern Newfoundland: New data and geotectonic implications. Canadian Journal of Earth Sciences, Volume 9, pages 452-459.

McGonigal, M.H.

1973: The Gander and Davidsville Groups: Major tectonostratigraphic units in the Gander Lake area, Newfoundland. M.Sc. thesis, Memorial University of Newfoundland, St. John's, 121 pages.

Potter, R.R

1955: Report on Caribou Pond - Central Newfoundland. NALCO unpublished report, Open file 2D/10 (38), Newfoundland Department of Mines and Energy.

Strong, D.F., Dickson, W.L., O'Driscoll, C.F. and Kean, B.F.

1974: Geochemistry of eastern Newfoundland granitoid rocks. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 74-3.

Strong, D.F.

1979: The Mount Peyton Batholith, Central Newfoundland: a Bimodal Calc-Alkaline Suite. Journal of Petrology, Volume 20, pages 119-138.

Williams, H.

1962: Botwood (west half) map area, Newfoundland. Geological Survey of Canada, Paper 62-9, 16 pages.

GRANDYS LAKE (110/15), NEWFOUNDLAND

by

L.B. Chorlton and D.B. Dingwell*

INTRODUCTION

Preliminary 1:50,000 scale mapping of the Grandys Lake area southeast of the Long Range Fault was started during 1979 (Chorlton, 1980a) and completed during the 1980 field season. Knight (1975) completed a 1:50,000 scale map of the Carboniferous rocks northwest of the fault. The area was previously included in a 1:250,000 scale reconnaissance and compilation map (Gillis, 1972). The adjoining Codroy (110/14, southeast part; Brown, 1976a), Port aux Basques (110/11; Brown, 1977) Rose Blanche (110/10; Brown, 1976b), La Poile River (110/16; Chorlton, in press) and La Poile (110/9; Chorlton, 1978) areas have been mapped on a 1:50,000 scale. Phair (1949) produced a 1:63,360 scale map of parts of the Codroy and Port aux Basques areas, and Riocanex has mapped their current holdings in the Port aux Basques, Rose Blanche, and Grandys Lake areas on a 1:19,680 scale (Harris, 1978, confidential).

The map area is not accessible by road, although numerous all-terrain vehicle tracks crisscross the western and northern ground; nine hunting cabins were noted. Most ponds are too shallow to be used by float planes so helicopters are the most viable form of rapid access. Mapping for this project was accomplished by traversing radially from helicopter-positioned fly camps, and by spot checking using a helicopter at the end of the field season.

GENERAL GEOLOGY

The oldest rocks in the area are mafic meta-igneous rocks (1) and medium to high grade metasedimentary rocks (2). These were variably deformed and brought to their regional metamorphic peak before the intrusion of voluminous tonalite, granodiorite, and granite (3) and, possibly, the Cape Ray Granite (4), a coarse grained quartz monzonite. Further deformation at medium to high metamorphic grade was responsible for the prominent regional fabric. This was followed by the emplacement of several leucogranite stocks (5, 8) and one porphyritic granite to diorite body (7), and by the eruption and deposition of the Windsor Point Group (6), a Devonian volcanic and sedimentary assemblage. The Windsor Point Group was sited along the Cape Ray Fault, a major fault which passes diagonally through the area. Further deformation involved the refolding of earlier structures, locally intense transposition, and the deformation of the Windsor Point Group within the Cape Ray Fault zone, bringing it into fault contact with the metamorphic terrain to the south. A major shear zone between the Long Range and Cape Ray Faults was reactivated at this time. Late rhyolite and diabase dikes postdate this deformation.

Brown (1973) suggested that the Cape Ray Fault may be a cryptic suture which juxtaposed Precambrian rocks from opposite sides of the early Paleozoic proto-Atlantic Ocean. Until Precambrian ages for the oldest rocks on either side of the fault are confirmed, this hypothesis is difficult to support, particularly because the metasedimentary schists and gneisses southeast of the fault strongly resemble parts of the Lower Paleozoic Bay du Nord Group (Chorlton, 1979, 1980a, in press). In this report, similar lithologies from both sides of the fault have been lumped together pending further investigation, and an attempt has been made to describe spatial variations on either side of the fault.

* Department of Geology, University of Alberta, Edmonton, Alberta, Canada.

LEGEND

DEVONIAN

8 Medium to coarse grained, pink, biotite leucogranite; associated aplite and pegmatite restricted to major shear zones.

7 Medium grained diorite to megacrystic granite and quartz monzonite.

6 Windsor Point Group: Deformed, low grade felsic and mafic volcanic rocks with sedimentary intercalations.

5 Fine grained, equigranular, pink granite with local carbonate-rich breccia and fracture fillings.

PRE-DEVONIAN?

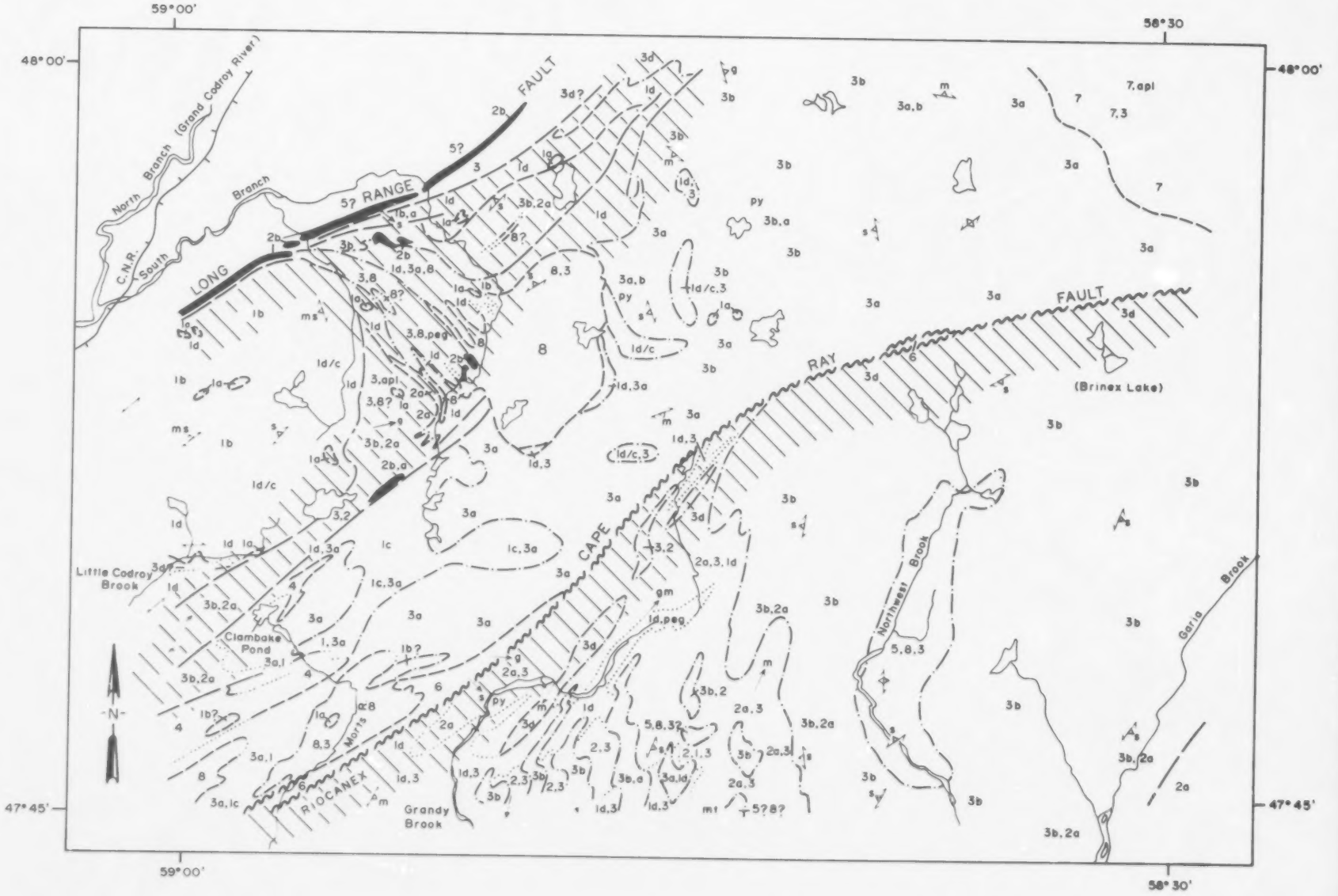
4? Cape Ray Granite: Megacrystic quartz monzonite; augen gneiss.

3 Synkinematic, equigranular, locally gneissic granitoid rocks showing local remobilization; 3a, tonalite with largely mafic inclusions; 3b, biotite granodiorite to granite with largely metasedimentary inclusions; 3c, coarsely garnetiferous granitoid with mixture of amphibolitic and metasedimentary inclusions; 3d, pink to white, muscovite-rich phases.

ORDOVICIAN AND EARLIER?

2 Amphibolite facies polydeformed metasedimentary rocks; 2a, largely semipelitic, but locally pelitic or quartzofeldspathic schists; 2d, marble, carbonate.

1 Variably metamorphosed and deformed mafic igneous rocks; 1a, altered dunite, peridotite; 1b, layered gabbro with anorthosite bands; 1c, unlayered gabbro, coarse grained subophitic gabbro, associated diabase, basalt; 1d, coarse to fine grained amphibolite with little or no remnant igneous texture; includes local anthophyllite and garnet bearing veined phases.


59°00'
58°30'
48°00'
47°45'
North Branch (Grand Codroy River)
C.N.R.
South Branch
LONG RANGE
FAULT
CAPE RAY FAULT
(Brinex Lake)
Little Codroy Brook
Clambake Pond
Morris
RIOCANEX
Grandy Brook
Northwest Brook
Garia Brook
-N-

Mafic and ultramafic rocks (1)

The mafic and ultramafic rocks are informally assigned to the Long Range Mafic-Ultramafic Complex (Brown, 1976a, 1976b, 1977). They include metamorphosed peridotite and dunite (1a), layered gabbro and anorthosite (1b), medium to coarse grained gabbro and pyroxenite with associated diabase or basalt and possibly some tuffaceous rocks (1c), and amphibolite with well developed regional tectonite fabrics (1d). The layered sequence (1b) is largely separated from the nonlayered complex (1c) by a prominent shear zone extending northeast from Little Codroy Brook in this map area; these units are part of a continuous sequence in the Codroy and Port aux Basques areas (Phair, 1949; Brown, 1976a, 1976c). Altered ultramafic rocks (1a) occur both within the layered sequence and throughout the area occupied by segments of the nonlayered complex (1c) included in synkinematic granitoid rocks (3).

Regional metamorphic modification is variable. Mafic rocks, especially those not engulfed in granitoid rocks, are well tectonized in and near shear zones. The layered sequence (1b) between the Long Range Fault and the "Little Codroy" shear zone appears little affected by regional metamorphism in the northwest, but grades into amphibolite (1d) with a strong L-S fabric toward the shear zone. A narrower highly tectonized belt occurs along the Long Range Fault. To the southeast of the shear zone, rafts of mafic rock surrounded by tonalite (3) have locally well preserved igneous textures which grade into weak to moderately well developed tectonite fabrics. In many places, mafic xenoliths are apparently undeformed, although the enclosing granitoid rock is foliated. The amphibolite within the shear zone south of the Cape Ray Fault displays a strong tectonic fabric, whereas undeformed metagabbro and coarse grained metapyroxenite occur as rafts in the synkinematic and younger granites along Northwest Brook.

The ultramafic rocks form rubbly, brown weathering outcrops within the layered sequence and the granitoid and inclusion complex to the east. They include partly to thoroughly altered wehrlite, feldspathic dunite, dunite, and harzburgite. Disseminated chromite is common, and crosscutting serpentine and enstatolite veins occur locally. Rodingite accompanies one serpentinite and metagabbro exposure near the "Little Codroy" shear zone, and was also observed within the layered gabbro wedge in the northern part of the shear zone and in the cliffs overlooking Mollichignic Brook.

The layered gabbros consist of gabbro, olivine gabbro, troctolite, anorthositic gabbro, and anorthosite. Bands range from 5 cm to 100 cm thick. Thin, rhythmic, graded beds were observed in a piece of troctolite float. A poorly to well developed foliation parallel or subparallel to the layering may reflect either a primary igneous lamination or the effects of high temperature deformation. Anorthositic gabbro bands have a cumulate texture, with poikilitic crystals of augite and magnetite surrounding plagioclase laths. Ferromagnesian-poor anorthosite or plagiogranite occurs as sheets mainly parallel to the layering. However, similar rock was observed locally crosscutting the layering and also forms the abundant plagiogranite stringers which cut the nonlayered gabbro complex east of the "Little Codroy" shear zone. Several quartz-feldspar-biotite pegmatites and one augite-hornblende-plagioclase pegmatite were observed in the central part of the layered block.

The nonlayered gabbro complex occurs as rafts of several kilometres in diameter and smaller inclusions in the granitoid terrane east of the "Little Codroy" shear zone. Two facies of this complex can be broadly distinguished in some areas: (1) mainly coarse and medium grained subophitic metagabbro intruded by metadiabase; and (2) possibly extrusive and hypabyssal mafic volcanic

rocks. The former is similar to mafic rocks underlying the Blue Hills of Couteau (Chorlton, 1980b), and the entire granitoid-mafic rock assemblage is remarkably similar to the Southwest Brook formation mapped by Herd (personal communication, 1980) in the Puddle Pond area (12A/5).

The massive metagabbro forms dark weathering outcrops of clinopyroxene metagabbro, metapyroxenite, and actinolite metagabbro irregularly cut by metadiabase or microdiorite. These rocks are net veined locally by profuse stringers of plagiogranite. The clinopyroxene metagabbro ranges from coarse to medium grained; the coarse grained phase is characterized by plagioclase laths ophitically to subophitically enclosed in large, uralitized clinopyroxene crystals, and the medium grained phase shows a less well developed subophitic texture. Medium grained metapyroxenite occurs in several areas and contains minor interstitial plagioclase. The actinolite metagabbro occurs as very coarse grained bands or lenses. The plagiogranite is white weathering and consists largely of plagioclase with minor quartz, sparse poikilitic crystals of pale green amphibole, and small, conspicuous, brown crystals of sphene, zircon, or allanite. East and southeast of Clambake Pond (local name) a very coarse breccia of many of the above rock types has been intruded by tonalite (3) and Cape Ray Granite (4).

Patches of metamorphically reconstituted, possibly extrusive and hypabyssal mafic volcanic rocks are intruded and incorporated into the granitoid terrain east of the large ovoid plug of late granite (8) in the north. Pillowlike structures were noted in one area. Most of these rocks consist of amphibolitized aphyric to plagioclase porphyritic basalt and/or diabase, medium grained metagabbro, and aphanitic, green to buff, color banded metatuff. The granitoid complex next to these patches contains abundant xenoliths of metabasalt or metadiabase, well banded metasedimentary schist, and deep red, chunky microcrystalline-garnet-quartz rock (ferruginous metachert ?).

Amphibolite with well developed L-S to S-L fabrics occurs mainly along or within shear zones. Extremely fine grained, black amphibolite with a steeply plunging mineral lineation and strong schistosity occurs along the southeast margin of the layered block. This amphibolite is cut by magnetite-rich plagioclase-clinopyroxene-hornblende pegmatite which appears to be less deformed and recrystallized than its host, and by pink, foliated granite. Within the northern part of the adjacent "Little Codroy" shear zone, similar fine grained amphibolite is tectonically interleaved with highly sheared pink granite (3d?) and potassium feldspar porphyritic granite (8b?). A more massive, tectonically bounded wedge of metagabbro, anorthosite, serpentinite, and rodingite with a steeply plunging L-fabric displays remnant igneous layering. These amphibolites apparently swing around to the northeast. Coarse grained anthophyllite and garnet-bearing amphibolite, interbanded with garnetiferous granitoid (3), appears locally at the eastern side of this shear zone.

Other noteworthy amphibolites occur within the shear zone to the southeast of the Cape Ray Fault. S-L tectonite fabrics in green hornblende-plagioclase rocks are locally overgrown by acicular amphibole; some of these rocks display spectacular development of gedrite and garnet. Several amphibolite outcrops exposed in a west-flowing tributary of Grandys Brook display a thick banding which reflects the alternation of coarse grained, feldspathic metagabbro and medium grained, relatively mafic metagabbro; this layering may have had a primary igneous origin.

Metasedimentary rocks (2)

Most of the pre-Devonian metasedimentary rocks are semipelitic to pelitic schist and migmatite, which commonly grade into injection gneisses and, thence, into metasedimentary inclusion-rich granitoid rocks (3). Siliceous siltstone is exposed in the southeastern corner of the area. Feldspathic quartzite and local carbonate inclusions are locally present in the granitoid terrain in the north-central part of the map area. Metachert (?) and banded semipelitic schist are associated with mafic inclusions in the granitoid terrain in the neighboring area to the south. Marble bands follow the face of the Long Range Fault escarpment, and are boudinaged and folded along the "Little Codroy" shear zone.

The semipelitic rocks underlying the area southeast of the Cape Ray Fault and within the southern part of the "Little Codroy" shear zone consist largely of garnet-biotite-quartz±sillimanite schists, commonly with thin migmatitic veining and thicker granitic injections. A megabreccia consisting of disoriented, previously folded, migmatite blocks underlies several hills at the apparent flexure of the latter shear zone. Kyanite appears near the Cape Ray Fault, and coarse grained staurolite-garnet-aluminosilicate-biotite-quartz schists are exposed between Grandys Brook and the fault.

The siliceous siltstone in the southeastern part of the area weathers buff to gray and is well banded, with beds 2 to 5 cm thick. It comprises the metasedimentary screens in the adjacent granitoid rock.

The quartzofeldspathic rocks in the north vary from well sorted quartzitic sandstone to fine grained, sheared felsite of unknown origin. Locally, the latter was thought to resemble portions of the Keepings Gneiss described by Cooper (1954) and Chorlton (in press).

The metachert (?) occurs as deep red, chunky inclusions in highly garnetiferous granitoid rock, and consists of microcrystalline intergrowths of almandine garnet and quartz. Associated banded semipelitic schists are both garnetiferous and garnet-free. Partly migmatized intraformational breccia composed of disoriented, angular, finely laminated blocks 5 to 10 cm in diameter was observed locally. Rare inclusions of siliceous schist were also noted.

The marble is a white, yellow, and pale gray weathering, very deformed and recrystallized carbonate grading to carbonate-diopside rock with locally abundant detrital quartz grains and pebbles. Some exposures are characterized by abundant tiny orange garnets, and others by fine grained graphite. In the Cape Ray Fault zone, the marble forms thick, openly folded beds or layers associated with carbonaceous semipelitic schist, garnet biotite gneiss, and amphibolite. Some of the carbonate-rich xenoliths in the granitoid rock along the northern margin of the area are banded.

Synkinematic granitoid rocks (3)

This term is applied to the voluminous, foliated, equigranular tonalite, granodiorite, and granite which was emplaced into the metabasic and metasedimentary terrain after the possibly diachronous attainment of the regional metamorphic peak. Hosts and inclusions range from entirely mafic meta-igneous rocks in some areas to largely metasedimentary in others, and many show evidence of regional metamorphism and even local migmatization before final incorporation into the granitoid phase. Some also show evidence of reaction and limited partial melting during postemplacement deformation. The proportion of inclusions to granitoid varies between 5% and over 70% within short distances. The granitoid rocks may have ranged considerably in

primary composition and texture, and were variously modified by penetrative deformation, recrystallization, and metasomatism at medium to high grade. Thin, relatively coarse grained, leucocratic stringers cutting the main granitoid phase in some areas possibly reflect limited remelting.

The transition from one granitoid and inclusion assemblage to another is only abrupt across major structural discontinuities. In general, tonalite is the dominant phase north of the Cape Ray Fault and tonalite, granodiorite and granite are all well represented south of it.

North of the Cape Ray Fault, coarse grained, weakly foliated biotite tonalite predominates where the rafts and inclusions of mafic rock make up most of the outcrop area; however, the tonalite displays a penetrative schistosity with an accompanying reduction in grain size in many areas along the Cape Ray Fault. Highly schistose, sparsely garnetiferous granodiorite contains many metasedimentary, and a few amphibolitic, partly assimilated xenoliths in the north-central part of the area. This phase becomes very coarsely garnetiferous to the south where metasedimentary and metamafic xenoliths intermingle, but garnet-poor where the inclusions are exclusively mafic. Gneissic banding is well developed toward the west in this terrain; sillimanite replaces the micaceous bands near the late granite plug (8b). Gneissic gray tonalite and/or granodiorite with screens of semipelitic schist along the "Little Codroy" shear zone passes northeastward into a locally pink, foliated granite and metasedimentary schist cut by rare veins of unfoliated equigranular granite (8?). Coarsely garnetiferous, strongly rodded granitoid schist underlies Stag Hill in the apparent bend of the "Little Codroy" shear zone, southwest of the hills underlain by megabreccia mentioned in the previous section. In the northern part of this shear zone, cataclastically foliated, garnet-free, pink granite is associated with highly deformed amphibolite (1d) and porphyritic granite (8?); gray, garnetiferous granitoid schist is associated with metasedimentary schists. Pink, fine grained, gneissic granite also occurs in Little Codroy Brook, where it intrudes metabasic rocks.

South of the Cape Ray Fault, the Rose Blanche Granite (Brown, 1975, 1976b) is the most abundant phase in the eastern half of the area. This body consists largely of medium grained, moderately to highly schistose, biotite-rich, gray tonalite and granodiorite characterized locally by a few small plagioclase phenocrysts. The penetrative schistosity grades westward into a well developed gneissosity, and migmatite screens become more abundant. Pink weathering, locally muscovite-bearing, gneissic granite occurs in sheets along the west end of the Cape Ray shear zone, and may possibly be correlated with the Port aux Basques Granite (Brown, 1976b, 1977). Similar, foliated, pink leucogranite appears to cut the gray granodiorite further east, particularly around the zone of younger granite intrusion along Northwest Brook. The Rose Blanche Granite becomes coarse grained and rich in coarse muscovite and porphyroclastic feldspar along the eastern half of the Cape Ray shear zone. Blebs of disseminated magnetite occur locally in both the gray and pink foliated granites.

Cape Ray Granite (4)

The name Cape Ray Granite (Brown, 1972, 1977) is here tentatively applied to a coarse grained, porphyritic granite to granodiorite which cuts the synkinematic granitoid, metabasite, and metasedimentary schist complex in the southwest part of the map area. The least deformed exposures are characterized by 3 cm and larger alkali feldspar and plagioclase phenocrysts in a mildly foliated, medium grained granodioritic

matrix. The intrusion lacks phenocrysts in rare patches near its northeast margin, but the coarse grained granitic dikes which cut the older rocks to the north are very porphyritic. Most of the unit has been severely deformed in this area to produce a pink to gray, feldspar "augen" schist.

Fine grained pink granite (5)

Pink, fine grained, granular granite and patches of slightly younger(?), pink, medium grained granite intruded the Rose Blanche Granite and older rocks in a broad intrusion zone centered around Northwest Brook. Discrete lenses of the fine grained granite cut the Rose Blanche Granite along and across the regional tectonic grain away from the main intrusion zone, and also occur in the La Poile River area (Chorlton, 1979, in press).

The fine grained granite consists of an allotriomorphic granular intergrowth of quartz and reddened alkali feldspars and plagioclase with less than 10 percent combined muscovite and chloritized biotite. Coarser grained granite is mineralogically similar, but may contain more coarse muscovite. Many exposures are affected by easterly, and rarely northerly, trending fractures. Zones of brecciation are common. Carbonate is abundant both as fracture and void fillings, and as breccia matrix. Shear and fracture zones in Northwest Brook locally show yellowish alteration and pervasive reddening of the late granite and the Rose Blanche Granite host. Scintillometer readings of two to three times background (total counts) were obtained, but did not correlate consistently with alteration.

Windsor Point Group (6)

The Windsor Point Group was defined by Brown (1975, 1976b, 1977) as a series of metasedimentary and metavolcanic rocks that overlies the Cape Ray Fault. The unit has been correlated with a similar assemblage, the Billiards Brook formation, which is exposed within the fault zone in the La Poile River area (Chorlton, 1979, in press) and has recently been mapped in the King George IV area (Kean and Jayasinghe, this volume). Latest Early Devonian or early Middle Devonian plant fossils (W.R. Forbes, personal communication; Dorf and Cooper, 1946) have been found in the latter areas. Therefore, the Windsor Point Group is also considered to be Devonian.

In the present area, the Windsor Point Group is exposed within the Cape Ray Fault zone in the southwest, but is pinched out along the fault in the central part of the area. A zone of mylonitization marks its contact with the metamorphic and granitoid terrain to the south. The presence of foliated tonalite, granodiorite, and metabasite clasts in Windsor Point Group and Billiards Brook formation conglomerates indicates unconformity with the granitoid inclusion terrain to the north (Brown, 1975, 1977; Chorlton, in press; Kean, personal communication). Its relationship with the medium grained pink biotite granite (8) is controversial (C. Mackenzie and D. Wilton, personal communication) since the contact coincides with a zone of fault gouge; however, the writer tentatively interprets the granite to be intrusive and the small clasts of fine grained pink granite contained in some of the clastic rocks to originate from the Windowglass Hill granite, a subvolcanic granite in the Rose Blanche map area. All three units are probably similar in age, however.

The Windsor Point Group is represented in the present area by felsic and mafic volcanic rocks, and sedimentary (including volcaniclastic) rocks. The felsic volcanic rocks include quartz porphyry, aphyric rhyolite tuff, quartz crystal tuff, and siliceous ash-flow tuff or agglomerate. Patches of rhyolite in the southwest and northeast are brecciated, and a rhyolite band along the southern contact with the

late, red, biotite granite (8) is intensely silicified and locally incorporated in fault gouge. The mafic volcanic rocks include mafic flows and/or dikes, and mafic tuffs. Although the mafic flows are highly sheared in most places, carbonate and chlorite filled vesicles were recognized locally. Mafic and felsic tuffs(?) are finely interbanded to the southwest of the map area. Chlorite schists exposed along the south side of the belt contain abundant carbonate and are believed to represent mafic volcaniclastic rocks. The sedimentary rocks consist of conglomerates which contain fragments of volcanic rock, fine grained granite (Windowglass Hill Granite?), and sedimentary rock. A conglomerate in the southwest corner of the area contains abundant angular fragments of felsic mylonite and pink felsite. The siltstone associated with ash-flow tuff is highly siliceous and thickly bedded. Graphitic slate occurs as interbeds in the conglomerate and volcanic rocks.

The Windsor Point Group is highly deformed within the Cape Ray Fault. The mafic volcanic rocks and associated chloritic schists are strongly foliated, and may be difficult to distinguish from older, mylonitized amphibolite with which they are locally in fault contact. A weak to strong planar fabric developed in most of the rocks is commonly chevron or kink folded, and an associated crenulation cleavage appears in some exposures. Rhyolite in closest contact with the fault contact to the south is brecciated.

Diorite and porphyritic granite and quartz monzonite (7)

Unit 7 refers to a body of diorite, porphyritic granite and porphyritic quartz monzonite which intrudes the foliated tonalite-metabasite terrain in the northeast corner of the map area. It extends into the adjacent corner of the La Poile River area (Chorlton, in press). Many screens of the tonalite and metagabbro/amphibolite complex are enclosed in the body, and patches of the intrusive diorite are exposed in the host terrain away from the main pluton, making the precise boundary hard to define.

Two main phases in this area, diorite and coarse porphyritic granite and porphyritic quartz monzonite, apparently grade into one another through a zone of increasing feldspar phenocryst or porphyroblast content, locally within several metres. The granite is mafic rich and contains large euhedral alkali feldspar laths with tiny altered plagioclase inclusions. The quartz monzonite contains zoned plagioclase phenocrysts in addition to the above assemblage. The diorite consists of a generally medium grained intergrowth of plagioclase, black hornblende, and up to 10 percent biotite. A weakly subophitic texture is developed in the finest grained phases. In many areas, sugary, pink aplite is associated with the intrusion and locally cuts the older rocks.

Pink, perthite-rich, biotite granite (8)

These granites form three plugs which truncate the main penetrative fabrics of their hosts north of the Cape Ray Fault. They are considered related in origin to several other granite plugs on either side of the Cape Ray Fault in adjacent map areas, being similar in lithology and timing of emplacement, *i.e.*, Petites Granite and Isles aux Morts Brook Granite to the south (Brown, 1976b), Chetwynd Granite (Cooper, 1954; Chorlton, 1978, 1980b), and several plugs on the north side of the fault in the La Poile River area to the east (Chorlton, in press). These granites are locally sheared and may be accompanied by minor pegmatite and aplite where they transect major late shear zones. Elsewhere, they are unfoliated and associated only with very fine grained quartz and sanidine porphyry dikes which may extend for over 5 km from the main body along planes of weakness.

In general, the granites are characterized by subequal to high modal ratios of perthitic alkali feldspar to plagioclase and by less than 5 percent biotite, the main ferromagnesian constituent. The bodies may range in texture from a medium grained, equigranular granite in which quartz tends to form relatively large, rhombic domains to a coarse grained, subequigranular granite in which the perthite laths tend to be subhedral and slightly larger than other grains, imparting a weakly feldspar-phyric aspect.

In the Chetwynd and Petites Granites, the medium grained phase grades into the more abundant coarse grained phase. The two bodies in the southwestern part of this map area, as well as the nearby Isle aux Morts Brook Granite, are both composed only of the medium grained phase; the larger ovoid plug to the north is composed of the coarse grained variety with a few small marginal patches of medium grained granite. The latter plug is also affected by a wide shear zone traversing its northwestern margin; this is probably related to a late stage of activity along the "Little Codroy" shear zone, along which apophyses of the porphyritic granite have been deformed. Shear zones related to the adjacent Cape Ray Fault also affect one of the southwestern plugs.

Late dikes (not shown)

Several slightly altered mafic and felsic dikes cut across the preceding units, following late northeast and east-southeast fracture trends. The mafic dikes are diabasic and have chilled margins. One atypical, north-trending mafic dike exposed along Northwest Brook contains highly reddened feldspars and substantial magmatic biotite. All of the dikes are altered, but are noticeably rich in sphene. The rhyolite dikes contain small twinned phenocrysts of plagioclase in a biotite-bearing microgranitic matrix, with or without fluidal textures. A lens of brecciated and kaolinitized rhyolite in Northwest Brook may represent a brecciated rhyolite dike, a volcanic breccia related to the Windsor Point Group, or a fault gouge related to the intrusion of the late, pink, carbonate-rich leucograntie (5).

STRUCTURAL AND METAMORPHIC EVENTS

It is probable that the timing of structural and metamorphic events is at least diachronous across a belt as wide as that between the Long Range and the south coast in the La Poile area. However, the sequence of events suggested by data from the neighboring areas (*e.g.* Brown, 1976b, 1977; Chorlton, in press) seems compatible so far with the field geology of the present map area. The order of structural and metamorphic events, with local age restraints, is summarized as follows:

1) The metavolcanic pile in the La Poile and La Poile River areas has been interpreted as part of a calc-alkaline island arc (Chorlton, in press) and corresponds to subduction (probably from the northwest) and accompanying deformation. Ages of 449 ± 20 Ma using the U/Pb zircon technique (Dallmeyer, 1979) and 459 + 18 Ma using the Rb/Sr whole rock technique (Wanless, personal communication) have been derived for different facies of the pile.

2) The metabasic and metasedimentary rocks (and nearby metavolcanic rocks) were deformed once and brought to their metamorphic peak(s) before the final emplacement of the voluminous synkinematic granitoid magmas. At least some of these granites were emplaced near their source (Dingwell, 1980), *i.e.*, derived from a little deeper in the metamorphic pile. The most common record of the earlier deformation is in the inclusion trails found in amphibolite facies porphyroblasts south of the Cape Ray Fault (Brown, 1975,1976a; Chorlton, in press). Those north of the fault have not yet been examined. The early

deformation affected the dated Middle(?) Ordovician rocks in the southeast, and must be Middle(?) Ordovician or later in that particular area.

3) The granitoid terrain was deformed and recrystallized under the prevailing medium to high grade metamorphic conditions, and developed a penetrative schistosity to gneissosity parallel to the strong S_2 schistosity of its hosts. This fabric strikes north to northwest in many areas. Block and/or strike-slip faulting probably accompanied the eruption and deposition of the Lower to Middle Devonian Windsor Point Group along the Cape Ray Fault, and postdated the second regional deformation. This suggests that the early multiple deformation and granitoid emplacement occurred before the Early or Middle Devonian.

4) The main effects of the third deformation are the deformation of the Windsor Point Group within the Cape Ray Fault, the folding of the strong regional fabric south of the fault and in the 'Little Codroy' shear zone, the locally intense transposition, or 'reworking', of earlier fabrics in the Rose Blanche (Brown, 1975, 1976b) and La Poile River (Chorlton, in press) areas, and the reactivation of major shear zones and faults. The metamorphic grade was maintained in the pre-Devonian rocks south of the Cape Ray Fault until this event. The Windsor Point Group was juxtaposed against the metamorphic terrain to the south, probably by a combination of left lateral strike-slip and reverse dip-slip fault movement. The Isles aux Morts Brook Granite, one of the late, pink, biotite leucogranite plugs (8), apparently postdated the refolding (Brown, 1976b), but all of the other plugs were affected by the shearing and/or faulting (Brown, 1976b, 1975; Chorlton, 1978, 1980b, in press). It is possible that the northernmost plug in the present area was actually synchronous with some of the late activity in the 'Little Codroy' shear zone. The Chetwynd Granite gives a U/Pb zircon date of 377±20 Ma in the La Poile - La Poile River area (Dallmeyer, 1979). Dates for the other granites may provide information about the timing of the third deformation event and the possibly diachronous geological history across the Cape Ray Fault.

5) Late north and east-northeast striking block faults and warping about north-south axes affected the rocks in this area (Brown, 1976b, 1977; Chorlton, in press). The late dikes appear to have been emplaced along a conjugate fault or fracture system. Folding and faulting of the Carboniferous strata to the west of the Long Range Fault (Knight, 1975, 1976) and subsequent thrusting of the rocks east of the Long Range Fault over warped Carboniferous rocks (Mook, 1926) indicate that the late activity must be Carboniferous or younger.

MINERALIZATION

Assessment of the Isle aux Morts Brook gold prospect along the Cape Ray Fault by Riocanex continued during 1980. This prospect occurs on a Brinex concession area, and is jointly optioned by Riocanex, Phillips Management, and Brinex. Sulphide showings in chlorite schists, which led to the exploration, first by Phillips Management, then by Amex Exploration, and finally by Riocanex, were found in the fault gulch near the high angle bend in Isle aux Morts Brook by George Bayly (prospector). The mineralization of current interest consists of gold-bearing quartz sulphide veins within the main shear zone of the fault (present area) and in the Windowglass Hill granite (Rose Blanche area to the south) (Bucknell *et al.*, 1980). According to Bucknell *et al.* (1980), metalliferous solutions originating from the granite migrated through the shear zone and encountered graphite bearing chlorite schists, an environment which is believed to have favored precipitation.

We did not find any significant new mineralization during the 1980 season. A blastomylonitic felsite (granite?) band with considerable disseminated pyrite occurs at the falls on Grandys Brook to the east of the main Riocanex showings, and numerous, extremely weathered, rusty mounds of pyritiferous, foliated granitoid rock are present in the north-central part of the area. Carbonate-hosted breccias and the alteration zones in the late granite intrusion zone along Northwest Brook may merit attention. Taylor (1970) investigated the bedrock source for stream sediment uranium anomalies located over the granitoid terrain near Brinex Lake (informal name). He concluded that biotite-rich lenses in the metasedimentary schists and the contact zone with the granodiorite were responsible for anomalously high uranium concentrations up to 85 ppm which were too low to be of economic interest.

ACKNOWLEDGEMENTS

Junior assistants, Margaret Steer and Gerry Sheppard, are thanked for a rewarding summer. Margaret lent a hand with the mapping in the end. Thanks are also extended to the crew at Viking Helicopters, especially to Gordon Aldie for numerous (successful) camp moves and to Juan Campos, who piloted us on the home stretch. Jim Barrett, Wayne Ryder, and Sid Parsons aided in the logistics from afar. Special thanks are due to D.B. (senior), Phyllis, and Cathy Dingwell, who provided a home for our paraphernalia, and kept us feeling organized in times of utmost confusion.

REFERENCES

Brown, P.A.
1972: Structural and metamorphic history of the gneisses of the Port aux Basques region, Newfoundland. Memorial Univeristy of Newfoundland, M. Sc. thesis, 113 pages.

1973: The Cape Ray Fault: a possible cryptic suture in southwest Newfoundland. Nature, Physical Science, Volume 246, pages 9-10.

1975: Basement-cover relations in southwest Newfoundland. Memorial University of Newfoundland, Ph.D. thesis, 218 pages.

1976a: Geology of the Rose Blanche, Port aux Basques, and part of the Codroy area, southwest Newfoundland. *In* Report of Activities for 1975. *Edited by* B.A. Green, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 76-1, pages 47-55.

1976b: Geology of the Rose Blanche map area (110/10), Newfoundland. Newfoundland Department of Mines and Energy, Report 76-5, 16 pages.

1976c: Ophiolites in southwestern Newfoundland. Nature, Physical Science, Volume 264, pages 712-715.

1977: Geology of the Port aux Basques area (110/11), Newfoundland Department of Mines and Energy, Report 77-2, 11 pages.

Bucknell, W.R., MacKenzie, C.B., and Wilton, P.H.C.
1980: Geology of the Cape Ray gold deposit, southwestern Newfoundland. Program with Abstracts, volume 5, page 43. GAC-MAC Joint Annual Meeting.

Chorlton, L.B.
1978: Geology of the La Poile area (110/9), Newfoundland. Newfoundland Department of Mines and Energy, Report 78-5, 14 pages.

1979: La Poile River map area (110/16) Newfoundland. *In* Report of Activities for 1978. *Edited by* R.V. Gibbons. Newfoundland Department of Mines and Energy, Report 79-5, 14 pages.

F2

1980a: Grandys Lake (110/15, west half). *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Report 80-1, pages 74-78.

1980b: Notes on the geology of Peter Snout (11P/13, west half), Newfoundland. Newfoundland Department of Mines and Energy. 9 pages to accompany map 80201.

in press: Geology of the La Poile River area (110/16), Newfoundland. Newfoundland Department of Mines and Energy, Report 80-3.

Cooper, J.R.
1954: The La Poile - Cinq Cerf map area; Newfoundland. Geological Survey of Canada, Memoir 276. 62 pages.

Dallmeyer, R.D.
1979: Geochronology - Insular Newfoundland mapping. Newfoundland Department of Mines and Energy. Progress Report 6/1/79 - 11/1/79, unpublished report, 57 pages.

Dingwell, D.B.
1980: The geology, geophysics and geochemistry of the Port aux Basques Granite. Memorial University of Newfoundland, unpublished B. Sc. (Honours) thesis, 125 pages.

Dorf, E. and Cooper, J.R.
1946: Early Devonian plants from Newfoundland. Journal of Paleontology, volume 17, pages 264-270.

Gillis, J.W.
1972: Geology of the Port aux Basques map area, Newfoundland. Geological Survey of Canada, Paper 71-42, 6 pages.

Harris, J.
1978: Cape Ray Project, Newfoundland. Report of 1978 Exploration Activities, volume II of II; for Riocanex, Riotinto Canadian Exploration Ltd. (CONFIDENTIAL).

Knight, I.
1975: Geological mapping, Carboniferous rocks, Cape Anguille Mountains, southwest Newfoundland. *In* Report of Activities for 1975. *Edited by* B.A. Greene. Newfoundland Department of Mines and Energy, Report 76-1, pages 10-18.

1976: Geology of the Carboniferous of the Codroy Valley and northern Anguille Mountains; *In* Report of Activities, 1975. *Edited by* B.A. Greene, Newfoundland Department of Mines and Energy, Report 76-1, pages 10-18.

Mook, C.C.
1926: Note on occurrence of thrust faulting in western Newfoundland. Geological Magazine, Volume 63, pages 348-350.

Phair, G.
1949: Geology of the southwestern part of the Long Range, Newfoundland. Princeton University, Ph.D. thesis, 165 pages.

Taylor, W.R.
1970: Geology and geochemistry of a uranium-rich area in southwestern Newfoundland. Memorial Univeristy of Newfoundland, M.Sc. thesis, 60 pages.

Winkler, H.G.F.
1976: Petrogenesis of Metamorphic Rocks. Published by Springer-Verlag (N.Y.) 1974, 320 pages.

LOWER PALEOZOIC GEOLOGY OF SOUTHWESTERN WHITE BAY

by

W.R. Smyth

INTRODUCTION

A reconnaissance mapping program of the southwestern White Bay region began in 1980 as part of a 1:50,000 scale compilation of previous work on the Cambro-Ordovician and Silurian sequences in the area. Four weeks field work was completed, mainly on the Cambro-Ordovician rocks.

The geology of the southern White Bay can be summarized as:

1. Precambrian granites and gneisses of the Grenville Long Range inlier. These rocks will not be studied in this project.

2. Cambro-Ordovician clastic-carbonate sequence, named the Coney Arm Group, that forms a narrow belt bordering the Grenville basement.

3. A granitoid complex named the Coney Head Complex that is unconformably overlain by Silurian strata.

4. The Silurian Sops Arm Group of bimodal volcanics, conglomerates, fluviatile sandstones, marine sandstones and calcalenites.

5. A Devonian (?) granitoid named the Gull Lake Granite.

6. Fluviatile sandstones and conglomerates of the Carboniferous Anguille Group. These were recently mapped in detail by Hyde (1979) and are not described here.

A major north-south trending fault system traverses the area and separates the Cambro-Ordovician sequence from the Coney Head Complex and the Sops Head Group. It shows evidence of early strike slip movements followed by later vertical displacements.

The area is of economic interest, as quartz veins cutting sediments and felsic volcanic rocks of the Sops Arm Group are auriferous and hosted the first gold mine in Newfoundland in 1903. A thin dolomite unit in the lower part of the Sops Arm Group hosts two lead prospects.

PREVIOUS WORK

The pioneering geological reconnaissance of the area was made by Murray (1881) who recognized the main geologic subdivisions. Howley (1918) later verified Murrays stratigraphy in the region of Sops Arm that was, at that time, being actively prospected for gold. Snelgrove (1935) investigated the gold prospects in detail and noted the association of the mineralization with quartz porphyry intrusives. Heyl (1937) produced the first geologic map of the area north of Sops Arm and proposed a nomenclature for the stratigrahpic units. Heyl considered the stratigrahpic sequences to be continuous and conformable, a view since shown to be incorrect by Lock (1969a) and Williams (1977). Betz (1948) mapped the area southeast of Sops Arm and provided a useful correlation with the Cambro-Ordovician and Carboniferous rocks of northern White Bay.

A fundamental revision of the stratigraphy was described by Lock (1969a, 1972a) who mapped the area from

Taylor's Pond to Coney Arm for a Ph.D. thesis. Lock showed that a major structural event, the Taconic Orogeny, separated deposition of the Silurian sequence from the Cambro-Ordovcian sequence. He modified Heyl's stratigraphy and proposed the nomenclature that has been essentially adopted by later workers. He described the volcanic stratigraphy of the Silurian Sops Arm Group in detail and demonstrated that many units previously described as intrusive are, in fact, welded ash flow tuffs (ignimbrites). He pointed out the possible association of the gold mineralization with volcanic activity.

Williams (1977) continuing his astute observations and synthesis of Newfoundland geology noted that the migmatites and greenschists described by Lock (1969a) in the northern part of the area were especially out of geologic context with the nearby Cambro-Ordovician platformal carbonate rocks. He discovered that the Silurian strata sit unconformably on igneous rocks of the misnamed "migmatite complex", which he interpreted as another Taconic allochthon in western Newfoundland.

Noranda Exloration, (summarized in Dimmell, 1979) following up stream sediment geochemical anomalies on the west side of the Gull Lake granite, discovered lead mineralization in a dolomitic limestone unit in the Silurian Sops Arm Group. They cut over 260 km of grid over this unit which lies close to the faulted Ordovocian-Silurian contact. Their detailed mapping has shown the complex nature of the fault system, and the stratigraphic control of the mineralization.

With this background information, it was thought that the geology could be reliably compiled on 1:50,000 scale maps augmented by limited field work. However, reconnaissance has shown the previous maps to be locally inaccurate, especially in inland areas, and further mapping is required which will be undertaken in 1981.

CONEY ARM GROUP (UNITS 2-4)

The Cambro-Ordovician clastic-carbonate sequence that unconformably overlies the Grenville basement is called the Coney Arm Group (Lock, 1969a; 1972a). It has been revised to include three formations (Williams, 1977), the Beaver Brook, Doucers, and Taylors Pond.

Beaver Brook Formation (Unit 2)

The Beaver Brook Formation (Heyl, 1937; Neale and Nash, 1963) forms the lowest formation and consists of quartzites and sandstones at the base, overlain by a white dolomite limestone unit, which is followed by a sequence of phyllites, mica schists and minor limestones.

Doucers Formation (Unit 3)

Phyllites of the Beaver Brook Formation pass transitionally upwards into a thick, previously undivided sequence of limestones, dolomites and orthoquartzites referred to as the Doucer's Formation (Heyl, 1937; Neale and Nash, 1963). Four members were recognized north of Little Coney Arm and the upper three are delineated in Figure 1.

The basal member consists of a sequence of thinly bedded, dark gray, limestones with interbedded, brown weathering, oolitic limestones and distinctive, brown-red weathering, gray dolomite beds from 0.5 to 1 m thick.

A fault of unknown displacement separates this member from a member containing limy slates, slates, dolomitic sandstones, calcareous sandstones, oolitic and oncolitic limestones and orthoquartzites, (Unit 3a). This sequence is well exposed in the coastal section from 1 km south of Cobbler Head to 0.8 km north of Little Coney Arm (Figure 1). Tops, determined from graded dolomitic sandstones, indicate that the steeply dipping to slightly overturned sequence youngs to the east. The quartzites occur in beds

LEGEND

CARBONIFEROUS

DEER LAKE GROUP

15 Undivided red conglomerate, sandstone and siltstone.

ANGUILLE GROUP

14 Undivided gray and red sandstone, conglomerate and gray to red siltstone.

DEVONIAN OR YOUNGER

13 **Gull Lake Granite:** Biotite, alkali feldspar granite.

SILURIAN (Middle to Late)

SOPS ARM GROUP (8-12)

12 **Natlins Cove Formation:** 12a, Fine grained argillaceous sandstone, gray siltstone, and limestone; 12b, felsic and minor mafic volcanic rocks.

11 **Simms Ridge Formation:** Gray siltstone and mudstone,minor calcareous mudstone.

10 **Frenchmans Cove Formation:** Bedded polymictic conglomerate and sanddstone.

9 **Jackson's Arm Formation:** Massive, cobble to boulder, polymictic conglomerate; minor volcanic rocks.

8 **Lower volcanic formations: 8a, White Iron Hills Formation:** rhyolite flows, and breccias; **8b, Main River Formation:** rhyolites, rhyolite breccias, mafic volcanics, minor polymictic conglomerate. **8c, Stony Hill Formation:** welded ash flow tuff, mafic volcanics, minor conglomerate. Undivided felsic and mafic volcanic rocks and minor sandstone, conglomerate, and dolomitic limestone.

PRE SILURIAN

7 **Coney Head Complex:** Tonalite granodiorite, diorite and gabbro. Intruded by composite dikes.

6 **Murrays Cove Schist:** Greenschist, mafic tuff and chert.

MIDDLE ORDOVICIAN TO CAMBRIAN

5 **Second Pond Melange:** Serpentinite and graywacke blocks in black shale matrix.

CONEY ARM GROUP (2-4)

4 **Taylors Pond Formation:** Slate, phyllite, and minor sandstone.

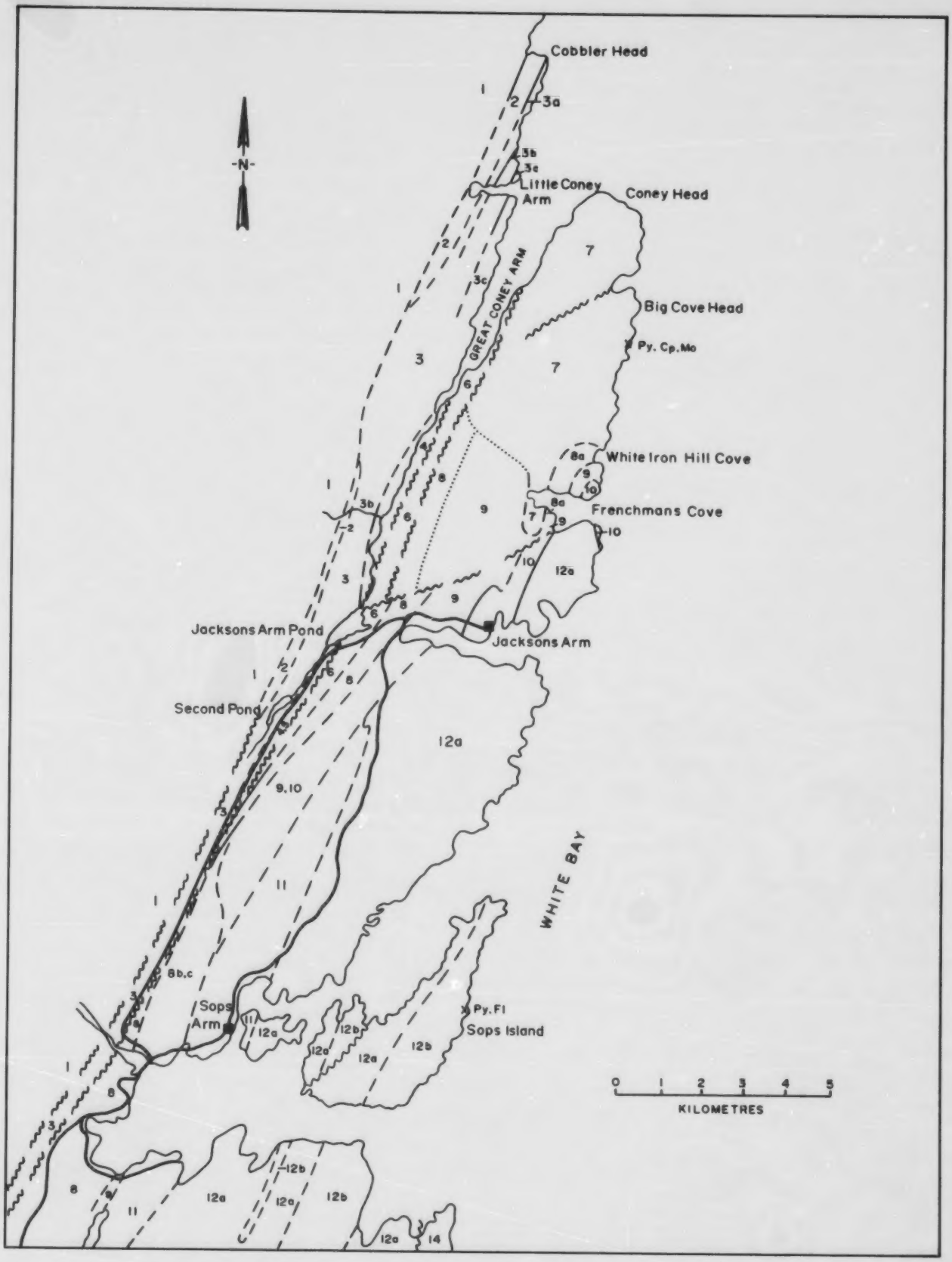
3 **Doucers Formation: 3a,** Calcareous slate, oolite and oncolitic limestone, orthoquartzite; **3b,** white dolomite, minor black limestone; **3c,** dark gray limestone, chert beds and nodules and marbles; **3,** undivided limestone, dolomite and marble.

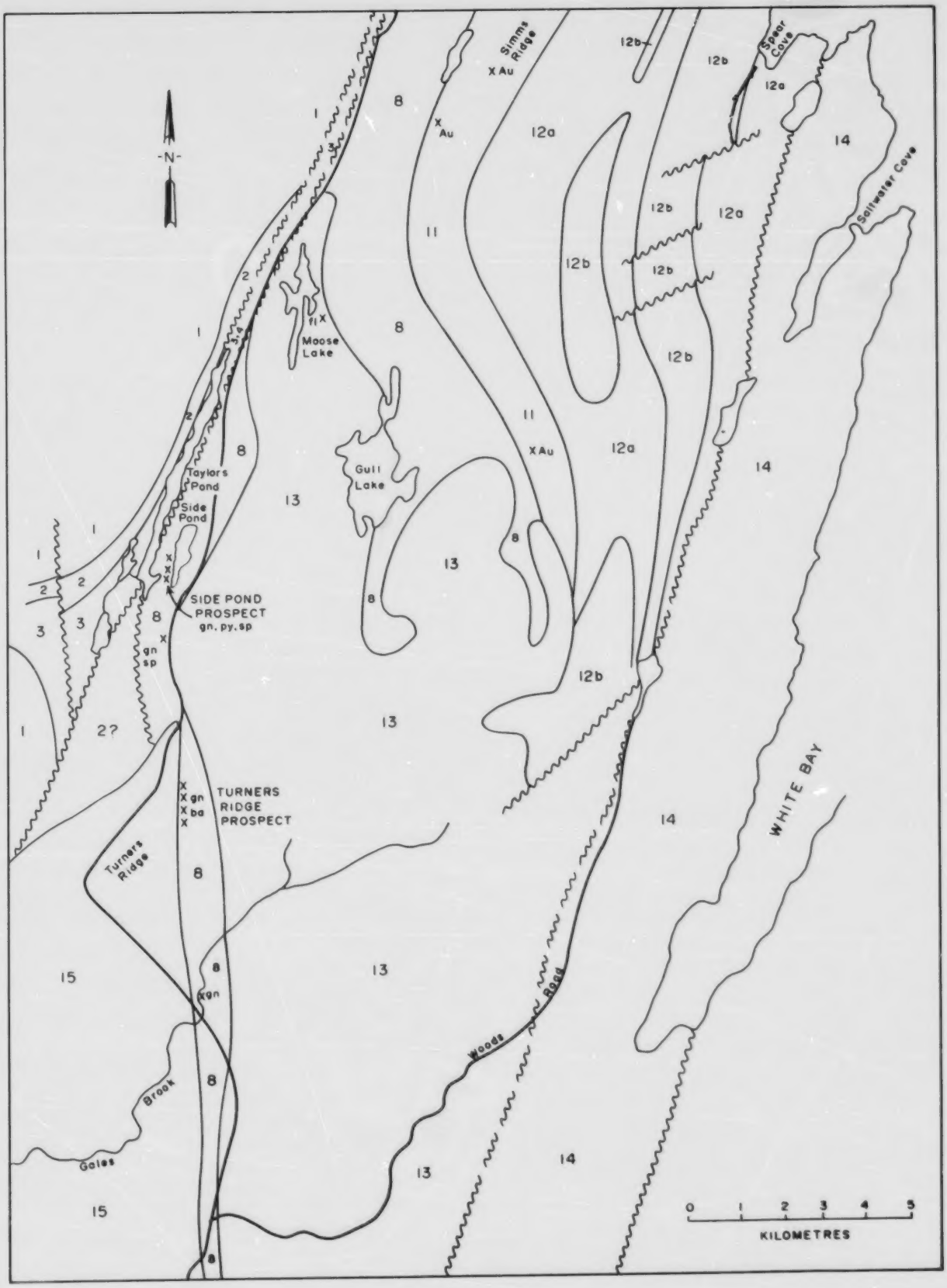
2 **Beaver Cove Formation:** Quartzite, sandstone, dolomitic limestone, phyllite and mica schist.

PRECAMBRIAN

LONG RANGE COMPLEX

1 Granite gneiss, granite and amphibolite.


Cobbler Head
-N-
Little Coney Arm
Coney Head
GREAT CONEY ARM
Big Cove Head
Py. Cp. Mo
White Iron Hill Cove
Frenchmans Cove
Jacksons Arm Pond
Jacksons Arm
Second Pond
WHITE BAY
Sops Arm
Py. Fl
Sops Island
0 1 2 3 4 5
KILOMETRES


-N-
Simms Ridge
XAu
Au
Speer Cove
Saltwater Cove
Moose Lake
Gull Lake
Taylors Pond
Side Pond
SIDE POND PROSPECT
gn. py. sp
gn sp
TURNERS RIDGE PROSPECT
gn ba
Turners Ridge
Rgn
Woods Road
Gales Brook
WHITE BAY
KILOMETRES
0 1 2 3 4 5

up to 4 m thick, are fine grained, thinly laminated, and rarely cross-laminated. One bed, 1.5 m thick, exhibits abundant soft sediment slumps. Similar quartzites and interbedded limestones outcrop in White Bottom Pond Brook north of Taylor's Pond (Figure 2).

Unit 3b of white, massive, well bedded dolomites overlies Unit 3a and is excellently exposed in the sea cliffs in Little Coney Arm. The dolomites occur in beds up to 1 m thick and display rare ripple marks and mudcracks. Minor interbeds of black limestone and black limy shales are present. Near the top of the dolomite unit, thin lenses (6 - 10 cm thick) of dolomite breccia occur along the tops of some beds. These were interpreted by Lock (1969a, 1973) as channel fills but are here considered to be the product of erosion over an indurated surface.

Lock (1973) described another 12 m thick channel fill in Unit 3b, exposed in a tibutary to Coney Arm River 3 km south of Great Coney Arm (Figure 1), which he interpreted as a channel feeder to the Cow Head Breccias. The breccia was largely inacessable in 1980 due to high water levels. It contains angular clasts of foliated white limestone and dolostone set in an dolomitized argillaceous limestone matrix. The haphazard arrangement of the foliation in the clasts indicates the host was deformed prior to breccia formation. Hence, the breccias are reinterpreted as either fault breccias or collapse breccias that formed after the regional penetrative deformation.

The dolomites pass transitionally up into a sequence of dark gray limestones with chert beds and nodules near its base (Unit 3c). The limestones are extensively burrowed. Single stromatolite mounds were observed in this unit in Little Coney Arm (Figure 1). Stouge (personal communication) recovered conodonts from samples of this unit collected at the southeast entrance to Little Coney Arm that indicate a Lower Ordovician (Canadian) age. From Little Coney Arm southwards, the dark gray limestones become highly tectonised, bedding is obscure, and small scale folds are common.

Taylor's Pond Formation (Unit 4)

Lock (1969a, 1972a) assigned the name Taylor's Pond Formation (Unit 4) to a sequence of slates, phyllites, micaceous schists and minor limestones that borders the carbonate belt on its eastern side. The phyllites underlie a linear valley that runs south from Great Coney Arm (Figure 1) and are poorly exposed. They are best seen in roadcuts on the Jackson's Arm - Sops Arm Road (Figure 1) where they are interbedded with a conspicuous 2 m thick limestone bed. The age and stratigraphic relations of the formation are unknown. Lithologically it resembles the Cambrian slates of the Beaver Brook Formation and also parts of the Middle Ordovician Goose Tickle Formation. Williams (1977) correlated the formation with the Goose Tickle Formation on the assumption that its present structural position at the top of the carbonate sequence is also its stratigraphic position. However, 60 km along strike to the north in Canada Bay the clastic - carbonate sequence occurs in a zone of imbricate thrusting (Smyth, 1973). Thus, in the White Bay area it is possible that the formation could be Cambrian in age and be in thrust contact with the underlying limestones.

SECOND POND MELANGE (UNIT 5)

A narrow zone of chaotic rocks (Unit 5) named the Second Pond Melange (Williams, 1977) occurs between the Taylors Pond Formation and the Silurian Sops Arm Group south of Jackson's Arm Pond (Figure 1). It consists of green sandstone, graywacke and serpentinized peridotite in a black slate matrix. Graphitic slates with quartzite blocks that outcrop in roadside exposures at the north end of Taylor's Pond (Figure 2) are not part of the melange as

described by Williams (1977) but are highly tectonized parts of the Sops Arm Group. An isolated block of serpentinized peridotite occurs near the south end of Taylor's Pond (Figure 2) and probably repesents the southerly continuation of the melange.

Melanges in western Newfoundland are associated with emplacement of Taconic allochthons and a similar origin was proposed for the Second Pond Melange by Williams (1977).

CONEY HEAD COMPLEX AND MURRAYS COVE SCHIST (UNITS 6 and 7)

Williams (1977) assigned the name Coney Head Complex to a complex of igneous and metamorphic rocks that lie to the east of the Coney Arm Group at Great Coney Arm. (Figure 1). The igneous rocks are bordered along their western margin by greenschists of the Murrays Cove Formation (Lock, 1969; 1972a), which Williams (1977) included in the complex. He stated that the "igneous rocks of the complex pass into the Murrays Cove Schist by structural and metamorphic gradation". The igneous rocks consist of gabbro, quartz diorite, granodiorite and tonalite.

A problem yet to be resolved in that area is the age and origin of the Coney Head Complex and the bordering schists. Williams (1977) discovered that the Silurian Sops Arm Group unconformably overlies the Coney Head Complex at White Iron Hill Cove (Figure 1). He noted the lithological similarities between the Murrays Cove Schist and other greenschists in western Newfoundland that occur structurally underpinned to transported ophiolites in the Hare Bay and Humber Arm Allochthons. This, and the discovery of ophiolite melange in the area, led Williams to suggest that the Coney Head Complex and the Murrays Cove schist were allochthonous and he correlated the igneous part of the complex with the transported Little Port Complex (Williams, 1975) in western Newfoundland.

However, there are a number of problems with such an interpretation.

1. A fault separates the Murrays Cove Schist from the Coney Head Complex, as first shown by Lock(1969a), and a gradation does not exist between them. For this reason the term Coney Head Complex (Unit 7) in this report is restricted to the intrusive part of the Complex and the Murrays Cove Schist (Unit 6) is excluded.

2. South of Jackson's Arm there is a gradation from weakly deformed mafic volcanic rocks at the base of the Sops Arm Group westwards into greenschists that are shown by Williams to be part of the Murrays Cove Schist. In this area the greenschists occur adjacent to a major fault, the Taylor's Pond Fault. Post-Silurian movements on this fault may have been responsible for the greenschist development.

The northern and western parts of the complex are extensively intruded by composite silicic and mafic dikes. The dikes are strongly sheared in contrast to the host which is weakly foliated to undeformed. Mafic dikes west of Coney Head have been converted to greenschists leading to the confusion in the distinction between the complex and the Murrays Cove Schist.

The Murrays Cove Schist consists predominantly of green to purple, laminated mafic tuffs with minor impure marbles and cherts. Red cherts in beds up to 7 cm thick were noted in Great Coney Arm. William's (1977) described lenses and pods of metagabbro in the greenschists in the same area.

The schists are cut by fine grained, buff coloured rhyolite dikes that in outcrop show the same strong penetrative schistosity as the host. Similar dikes

also cut the Coney Head Complex and are probably related to acid magmatism of the Sops Arm Group. In this case the main deformation of the schists and the Complex would be post-Silurian (Acadian) and not Taconic as suggested by Williams (1977).

SOPS ARM GROUP (UNITS 8-12)

The geology of the Sops Arm Group is relatively well known from the work of Lock (1969a, b; 1972a, b) and more recently from detailed mapping in the lower part of the group south of Taylor's Pond (Fig. 2) by Noranda geologists (Dimmell, 1979).

The type section at Sops Arm contains four formations but there are considerable lateral facies variations within the group. The basal volcanic unit (Unit 8) was divided by Lock (1969b) into the White Iron Hill, Main River and Stoney Hill formations. They are all probably lateral equivalents and consist of mixed silicic and mafic volcanic flows, breccias and pyroclastic rocks with minor interflow conglomerate and sandstone horizons. Near Jackson's Arm Pond (Figure 1) and from Taylor's Pond southwards (Figure 2) Noranda mapped out a dolomite member within the lower volcanic unit (Unit 8) that is host to sub-economic lead mineralization over a strike length of 15 km.

The immediately overlying formations, consist of a lower unit (Unit 9) of massive, boulder and cobble conglomerate (Jackson's Arm Formation; Heyl, 1937; Lock, 1969b) overlain transitionally by an upper unit (Unit 10) of bedded conglomerates and sandstones (Frenchman's Cove Formation; Lock, . 1969b). The conglomerates are polymictic with clasts of rhyolite, porphyry, shale, mafic lava, chert, sandstone, granite and gneiss.

The uppermost formations of the group consist of shallow marine sandstones, shales and calcarenites named the Simms Ridge and Natlins Cove Formations (Hyel, 1937; Lock, 1969a,b, 1972b). Shales of the Simms Ridge Formation (Unit 11) show characteristic brown weathering spots caused by disseminated siderite. The Natlins Cove Formation (Unit 12) is the most extensive of the group and consists of a lower and upper sandstone member separated by five, mixed silicic and mafic volcanic members (Lock, 1969b; 1972b). Carbonate beds are common in the formation and are abundantly fossiliferous containing corals and brachiopods that indicate middle to late Silurian age (Lock, 1972a).

GULL LAKE GRANITE (UNIT 13)

The Sops Arm Group is intruded by a large Devonian (?) biotite, alkali feldspar granite named the Gull Lake Granite (Lock, 1969a). This is the most westerly upper Paleozoic granite in the Humber Zone of the Newfoundland Appalachians.

Lock 1969a described an area of amphibolite adjacent to the northeastern margin of the granite which he interpreted as an inlier of Grenville basement. The amphibolites display relict pillow structures and are overlain without any apparent break by a mixed sequence of mafic tuffs and rhyolites in which the metamorhpic grade transitionally decreases to greenschist within 0.5 km from the granite. The amphibolites possess a single cleavage like the rest of the Sops Arm Group to which they are here assigned. Their higher metamorphic grade is explained simply by contact metamorphism related to granite intrusion.

MINERALIZATION

Pegmatitic quartz gabbros of the Coney Head Complex south of Big Cove Head (Figure 1) contain small patches of interstitial chalcopyrite mineralization. In the same area, cross-cutting quartz-feldspar pegmatites contain minor molybdenite, pyrite, and chalcopyrite mineralization.

The first gold mining in Newfoundland took place in the Sops Head area (Figure 2) in 1903 when quartz veins cutting shales of the Simms Ridge Formation were exploited. This mine, known as the Browning Mine, only produced 149 ounces of gold. The quartz veins contain minor galena, pyrite and chalcopyrite but no visible gold (Snelgrove, 1935; Heyl, 1937). Another prospect, the Simms Ridge prospect, occurs in quartz veins and shear zones that cut a rhyolite flow. It has yet to be investigated in this study.

The Noranda lead prospects occur in a dolomite unit within the basal volcanic formation of the Sops Arm Group (Figure 2) In the Turners Ridge prospect the mineralization occurs as a network of galena-barite veins up to 5 cm wide cutting brecciated dolomite. The Side Pond Prospect consists of quartz-barite veins containing galena, pyrite and sphalerite cutting unbrecciated dolomite.

The Gull Lake Granite contains rare, narrow, fluorite veins near Moose Lake.

ACKNOWLEDGEMENTS

Peter Dimmell of Noranda Exploration is thanked for making his geological knowledge of the area freely available and for use of their base camp. Jim Hibbard and Cyril O'Driscoll reviewed the manuscript. Wayne, Sid, and Jim are thanked for looking after the logistics in their usual fine style.

REFERENCES

Betz, F.J. Jr.
1948: Geology and mineral deposits of southern White Bay Newfoundland Geological Survey Bulletin 24, 26 pages.

Dimmell, P.M.
1979: Noranda - Brinex Joint Venture, Sops Arm - White Bay Concession. Report Jan. 10 - Dec. 31, 1979. Private report.

Heyl, G.R.,
1937: The geology of the Sops Arm area, White Bay, Newfoundland. Newfoundland Department Natural Resouces, Gology Section Bulletin 8, 42 pages.

Howley, J.P.
1918: Report for 1902, Chapter 22. Geological Survey of Newfoundland.

Hyde, R.S.,
1979: Geology of Carboniferous strata in portions of the Deer Lake Basin, western Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 79-6, 43 pages.

Lock, B.E.
1969a: The Lower Paleozoic geology of western White Bay, Newfoundland, 2V. Unpublished Ph.D. thesis, Cambridge University, Cambridge, England, 343 pages.

1969b: Silurian rocks of west White Bay area, Newfoundland. *In* North Atlantic - Geology and Continental Drift. *Edited by* M. Kay. American Association of Petroleum Geologists, Memoir 13, pages 433 - 442.

1972a: Lower Paleozoic history of a critical area; Eastern margin of the St. Lawrence Platform in White Bay, Newfoundland, Canada. International Geological Congress 24th. Montreal, section 6, pages 310 - 324.

1972b: A Lower Paleozoic rheoignimbrite from White Bay, Newfoundland. Canadian Journal of Earth Sciences, Volume 9, pages 1495 - 1503.

1973: The source of the Cow Head breccias of western Newfoundland. New evidence. Journal of Geology, Voume 81, pages 743 - 746.

Murray, Alexander
1881: Report for 1864, Geological Survey of Newfoundland, London, 536 pages.

Neale, E.R.W., and Nash, W.A.
1963: Sandy Lake (east half) Newfoundland. Canada Geological Survey of Canada, Paper 62-28, 40 pages.

Smyth, W.R.
1973: The stratigraphy and structure of the southern part of the Hare Bay Allochthon, NW Newfoundland. Unpublished Ph.D. thesis, Memorial University of Newfoundland.

Snelgrove, A.K.,
1935: Geology of gold deposits of Newfoundland. Newfoundland Department of Natural Resources, Geological Section Bulletin 2, pages 37-44.

Williams, Harold
1975: Structural succession, nomenclature, and interpretation of transported rocks in western Newfoundland. Canadian Journal of Earth Sciences, Volume 12, pages 1874-1894.

1977: The Coney Head Complex: another taconic allochthon in west Newfoundland. American Journal of Science, Volume 277, pages 1279 - 1295.

ECONOMIC GEOLOGY OF THE WESTERN HERMITAGE FLEXURE, NEWFOUNDLAND

by

H. Scott Swinden

INTRODUCTION

Investigation of mineral occurrences of the Hermitage Flexure and their regional geologic setting was continued during the 1980 field season. This is the second year of a project designed to classify the various mineral deposits of the area, evaluate their economic significance in terms of the regional geology, and provide a model of metallogeny throughout the Flexure that will prove useful in the search for economic mineral deposits.

A limited amount of work was carried out during 1980 in the Bay d'Espoir area to supplement work completed during 1979 (Swinden, 1980). Most of the season, however, was spent in the western Hermitage Flexure area between La Poile Bay and Grandys Brook (Figure 1). Of primary interest in this area were the Bay du Nord and La Poile Groups (Cooper, 1954; Chorlton, 1978, 1979a), volcano-sedimentary sequences of probable Lower-Middle Ordovician age which are host to a number of previously reported mineral occurrences (Cooper, 1954; Douglas and Hsu, 1976). In addition, investigations were carried out on the Keepings Gneiss and the Northern Granite near Prospectors Pond and the headwaters of Morg Keepings Brook, where pyritic sulfide occurrences have been previously reported.

Regional mapping in the area was first carried out by Cooper (1954), who mapped the area between La Poile Bay on the west and Couteau Bay on the east at a scale of one inch to one mile. Much of the stratigraphic nomenclature presently in use dates from his work; he also provided the first comprehensive descriptions of the mineral occurrences in the area. 1:250,000 mapping of the southwest coast was carried out in the Burgeo-Ramea area (11P) by Riley (1959) and in the Port aux Basques area (110) by Gillis (1972) for the Geological Survey of Canada. 1:50,000 mapping of the southwest coast was started by the Mineral Development Division in 1977 and to date has been completed in the La Poile (110/16), La Poile River (110/9) and Peter Snout, west half (11P/13) map areas (Chorlton, 1978, 1979b, 1980, in press), where most of the present work was carried out.

The 1980 field work in the western Hermitage Flexure was equally divided between the La Poile Group, where work was concentrated in the area of Cinq Cerf Brook and west of Grandys Brook, and the Bay du Nord Group northeast of La Poile Bay. A brief period at the end of the season was spent in the Keepings Gneiss and the Northern Granite north of the Cape Ray Fault.

GENERAL GEOLOGY

The oldest rocks in the area appear to be sheared, foliated units of metagabbro, layered metagabbro, metapyroxenite and related volcanic rocks of Ordovician or older age, which occur as disrupted lenses in the Bay du Nord and La Poile Groups (Chorlton, 1978, 1980).

The oldest stratified successions in the western Hermitage Flexure consist of Ordovician volcanic, subvolcanic and sedimentary rocks (and their metamorphosed equivalents) assigned to the La Poile and Bay du Nord Groups. Both sequences have been traced from the area of La Poile Bay north and east to Grandys Brook, and regional geologic compilations by Smyth (1979, 1980)

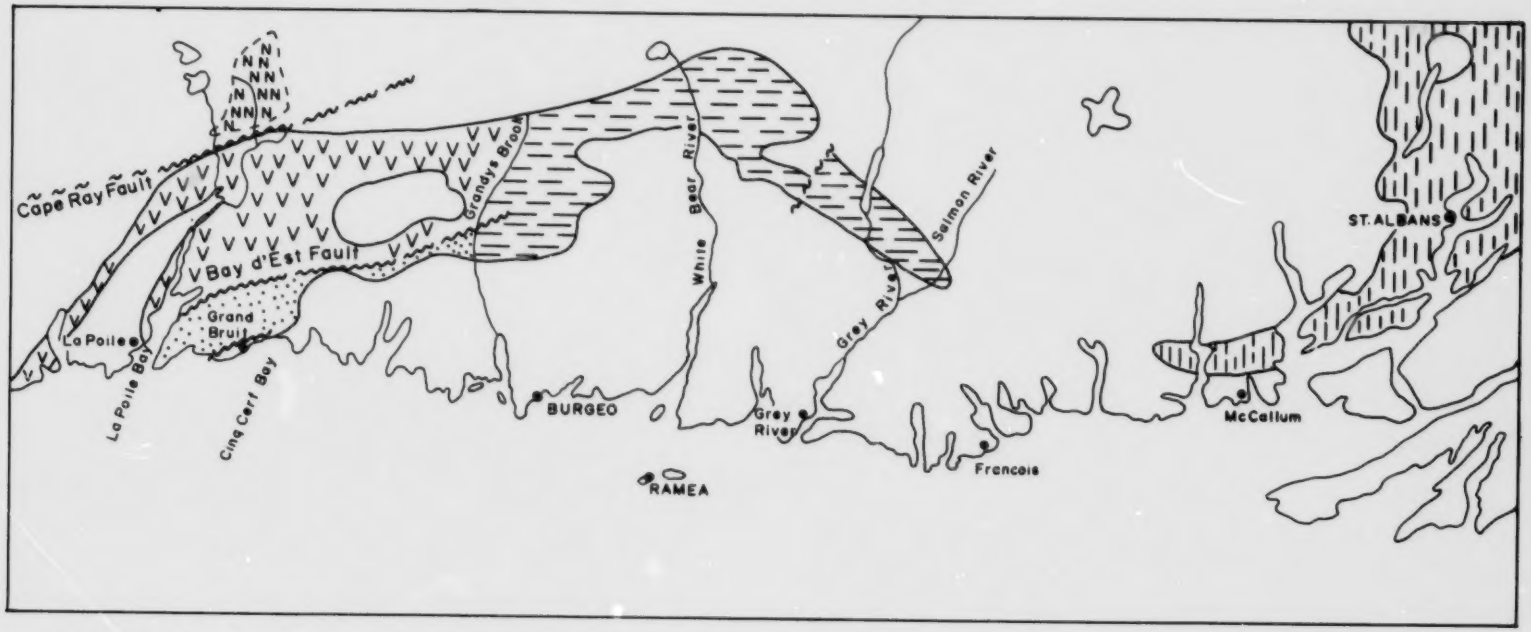
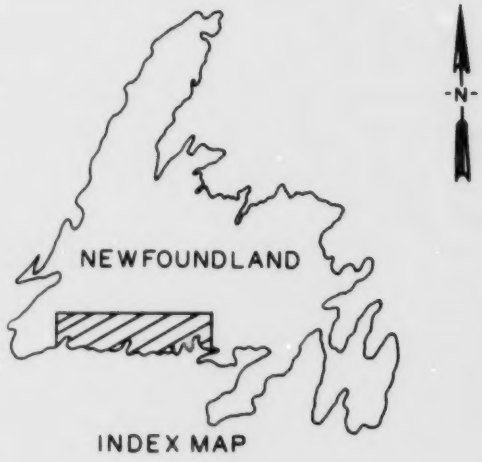


FIGURE I. Location of Ordovician Volcano-Sedimentary sequences in the Hermitage Flexure

- Bay du Nord Group
- La Poile Group
- Undivided
- Baie d'Espoir Group
- Keepings Gneiss

km 0 25 50 km



suggest that they may continue along strike to the area east of Grey River. The two sequences are considered to be contemporaneous (Chorlton, 1979, in press).

The La Poile Group, as redefined by Chorlton (1978), comprises a thick sequence of volcanic and sedimentary rocks bounded to the north by the Bay d'Est Fault and to the south by granitoid rocks along both faulted and intrusive contacts. The La Poile Group has been subdivided into two units: the Georges Brook Formation (which includes all the stratified rocks of the La Poile Group) and the Roti Granite. The stratigraphically lower parts of the Georges Brook Formation consist of both mafic and felsic volcanic rocks interbedded with lesser clastic sedimentary (probably epiclastic) rocks. These pass upwards (*i.e.* to the north and northwest) into a thick pile of dominantly subaerial felsic volcanic rocks consisting of rhyolitic flows, ash flows, crystal-lithic tuff, volcanic breccia and minor epiclastic rocks. These rocks have been polydeformed and regionally metamorphosed to a peak grade in the greenschist facies. No fossils have been discovered in the Georges Brook Formation, but mafic and felsic volcanic rocks have yielded a Rb/Sr whole rock age of 459 $\pm$ 18 Ma (Wanless, personal communication, quoted in Chorlton, 1980). The Georges Brook Formation is intruded by the Hawks Nest Pond Porphyry, which has yielded a U/Pb age of 410 $\pm$ 20 Ma (Anon, 1980).

The Roti Granite (Cooper, 1954) occupies the basal part of the La Poile Group in the La Poile and parts of the Peter Snout map areas. It is dominantly a medium grained granodiorite but locally displays both porphyritic and leucogranitic phases. The Roti Granite occurs as fine grained dikes within the lower part of the Georges Brook Formation, clearly intrudes the volcanic rocks along their mutual contact, and also appears as boulders in conglomerates higher up in the La Poile Group. It is deformed and metamorphosed with the volcano-sedimentary rocks of the La Poile Group and is interpreted as being subvolcanic to them (Chorlton, 1978, 1980).

The Bay du Nord Group consists of a succession of metasedimentary, metavolcanic, and subvolcanic rocks bounded to the south by the Bay d'Est Fault and to the north by the Cape Ray Fault and various syntectonic granitoid rocks. Volcanic rocks within the Bay du Nord Group are mainly felsic in composition, consisting of rhyolite, felsic tuff and lapilli tuff and occasional volcanic breccia. Clastic sedimentary rocks ranging from siltstone and shale to graywacke and conglomerate are commonly interbedded with the volcanics and, in many areas, comprise most of the succession.

Two stratified rock units have been informally included in the Bay du Nord Group: the Piglet Brook Rhyolite and the Dolman Formation. The Piglet Brook Rhyolite (Chorlton, 1980, in press) consists of pink to cream-colored, massive rhyolite which can be traced from south of Big Pond to the Blue Hills of Couteau. The Dolman Formation (Chorlton, 1978, 1980, in press) comprises mainly felsic crystal tuff and crystal-lithic tuff with lesser interbedded clastic sedimentary rocks. The Dolman Formation is thought to be the uppermost exposed unit of the Bay du Nord Group as it does not appear as clasts in conglomerates which are widespread throughout the other parts of the succession (Chorlton, in press).

The Baggs Hill Granite (Chorlton, 1979a, 1980, in press) is a name given to several subvolcanic intrusive bodies which are included in the Bay du Nord Group (Chorlton, 1979). It ranges from medium grained granite to granophyre and quartz-feldspar porphyry; although it intrudes the Bay du Nord Group, it is also present as clasts in intraformational conglomerates and, hence, is interpreted to be subvolcanic in origin (Chorlton, 1979, in press).

The Bay du Nord Group has been polydeformed and has attained a peak regional metamorphic grade of upper greenschist to middle amphibolite facies (Chorlton, 1979a). It has yielded no fossils to date, but volcanic rocks of the Dolman Formation have been dated by U/Pb in zircons as 449 + 20 Ma (Anon, 1980), suggesting contemporaneity with the La Poile Group.

The youngest stratified rocks in the area are mafic and felsic volcanic rocks, clastic sedimentary rocks and mafic to ultramafic intrusive rocks of the informally named Billiards Brook complex (Chorlton, 1979a). These occur only within the trace of the Cape Ray Fault zone and have been strongly deformed by late movements on the fault. Plant fossils in clastic sedimentary rocks of the Billiards Brook complex suggest a Lower Devonian age (Chorlton, 1979a; Dorf and Cooper, 1946).

A wide variety of syn- and posttectonic granitoid rocks are found in the western Hermitage Flexure area ranging in composition from gabbro to granodiorite and granite (Chorlton, 1978, 1980, in press). Variably deformed granitoid rocks include coarse grained porphyritic biotite granite, equigranular leucogranite, and granodiorite, probably Devonian or older, as well as crosscutting monzonite to quartz diorite and granite which are considered to be Devonian or younger in age.

MINERALIZATION IN THE LA POILE GROUP

Two principal areas of mineralization have been recognized in the La Poile Group; the first in the vicinity of Cinq Cerf Brook and the second in the area west of Grandys Brook. These are treated separately below.

Mineralization in the Cinq Cerf Brook area has been known since approximately 1902, when John and Samuel Billiard of Grand Bruit discovered sulfides on what is now the Chetwynd Property (Snelgrove, 1935). Three shafts were sunk on the property at that time but by all accounts, no ore was ever shipped. Work in the area since has been concentrated on five principal showings; the Chetwynd, Copper Shaft, Iron Hat, Hope Brook and Woodmans Droke prospects. Accounts of the work performed can be found in Reading (1933), Snelgrove (1935), Douglas *et al.* (1940), Cooper (1954), Pouliot (1957) and Chorlton (1978). The most detailed and exhaustive lithologic descriptions and an excellent map at a scale of 1:15,840 (1" = 1320') of the area can be found in Pouliot (1957).

The Cinq Cerf Brook area is underlain mainly by volcanic and sedimentary rocks of the Georges Brook Formation. In this area, the lower part of the formation consists of a thick sequence of mafic volcanic flows and pyroclastics with interbedded metagraywacke and slate and minor felsic tuff. The exposed base of the sequence is intruded by the Roti Granite and dikes related to this granite are found throughout the lower part of the Georges Brook Formation. The dominantly mafic volcanic-sedimentary sequence passes upwards into a thick sequence of dominantly subaerial rhyolitic flows which form the Highlands of Grand Bruit and the whole package is intruded by dikes and sills related to the Hawks Nest Pond Porphyry (Pouliot, 1957). Northeast of Cinq Cerf Brook, the Georges Brook Formation is truncated by the Chetwynd Granite, a posttectonic, medium grained, biotite granite.

Of particular interest in the Cinq Cerf Brook area are two, apparently conformable horizons of silicified, sericitized and pyritized felsic rocks, each of which has a strike length of over 3 km and which, between them, host four of the five showings mentioned above (Figure 2). Lithologically, they range from highly sheared, altered, pyrophyllitic, siliceous schist to hard, aphanitic rock which appears to be rhyolite. Scattered faint bluish quartz eyes and small feldspar laths are

LEGEND

DEVONIAN (?) EARLIER

5 **CHETWYND GRANITE:** Pink biotite granite

4 **CINQ CERF COMPLEX:** Equigranular granodiorite

3 **HAWKS NEST POND PORPHYRY:** Quartz-feldspar porphyry

ORDOVICIAN (?)

LA POILE GROUP

2 **ROTI GRANITE:** Equigranular to porphyritic subvolcanic leucogranite

GEORGES BROOK FORMATION

1F - Dominantly flow banded rhyolite, felsic crystal-lithic tuff

1E - Graywacke; lesser argillite, conglomerate

1D - Coarse, polymictic boulder conglomerate

1C - Laminated, fine grained felsic tuff

1B - Mafic volcanic rocks, green chloritic metasediments, lesser felsic volcanics

1A - Silicified, sericitized, pyrite rhyolite (?)

MINERAL OCCURRENCES

A - Chetwynd Propect: Cu, Au, Py

B - Copper Shafts: Cu, Py

C - Iron Hat: Py

D - Hope Brook: Py

E - Woodmans Droke: Pb, Zn, Py

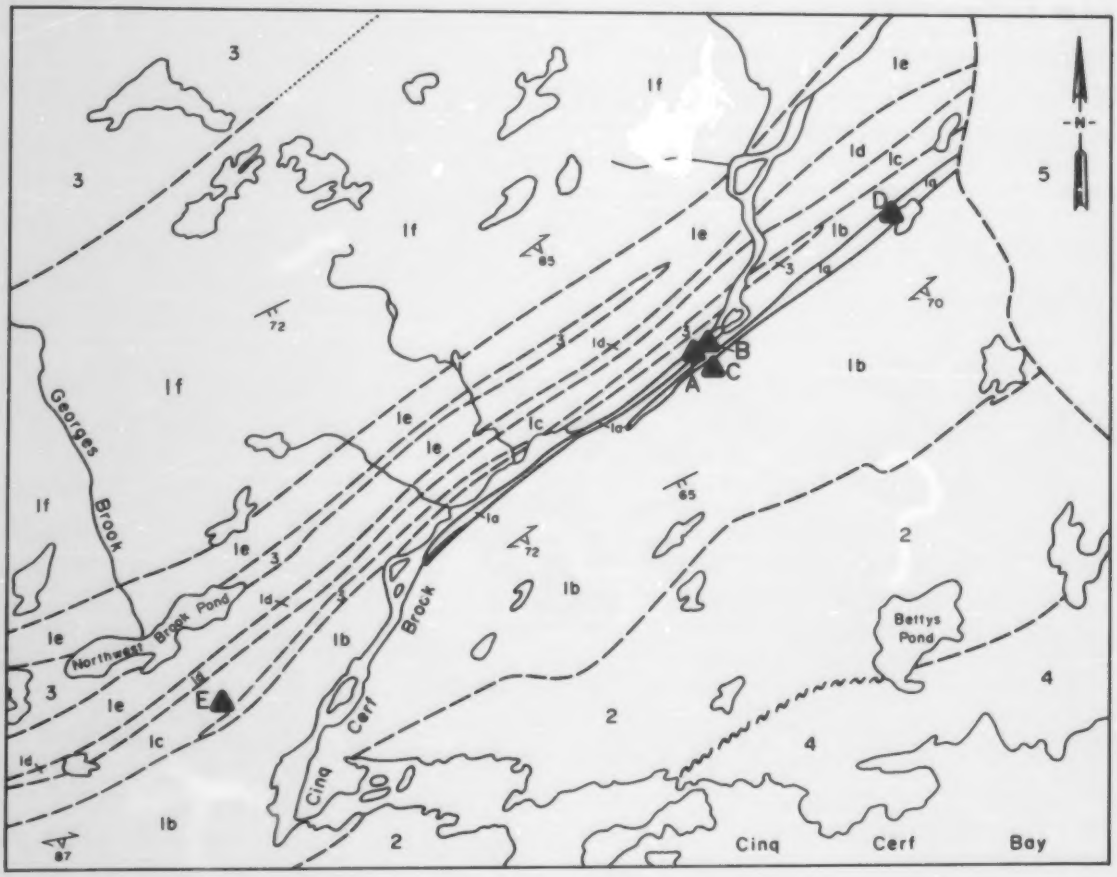


Figure 2. Geology and mineral deposits of the Cinq Cerf Brook area

Scale

0 1 2

Km

present and the two horizons are heavily iron stained and deeply leached along their exposed strike lengths. They may have formed as either high level granitic sills or rhyolite flows; field evidence is not conclusive for either interpretation. The mineralized horizons are hosted by fine grained chloritic schist of the lower division of the La Poile Group in this area. Their distribution is shown in Figure 2 and, because of their economic significance, they are discussed separately below. For convenience in the following discussion, the northwesterly horizon is referred to as "A horizon" and the southeasterly horizon as "B horizon".

The mineralized "A horizon" outcrops in the bed of Cinq Cerf Brook over a strike length of approximately 4 km. Where relatively fresh (unweathered), it generally consists of buff to gray, cherty, aphanitic rhyolite, but much of the horizon has been sheared and altered so that it commonly has the aspect of a fine grained, rhyolitic tuff. The northeast end of this horizon is not exposed but, in the southwest end, there is a gradual feathering out of the felsic horizons and the most southwesterly exposures comprise thin beds and lenses of altered felsic tuff in the chloritic schist host. The horizon is iron stained along its entire length although, in surface exposures, most of the pyrite has been weathered out, leaving cubic vugs. Two principal showings containing copper and gold are known within the "A horizon", the Chetwynd and Copper Shaft prospects, both of which occur near the northeast end of the horizon (Figure 2). The mineralization is presently exposed in the banks of Cinq Cerf Brook and in an open cut across the mineralized zone. At the Chetwynd Prospect, a shaft 27-30 metres deep, was sunk in the early 1900's with a southerly directed crosscut at between 10 and 15 metres and a northerly directed crosscut near the bottom of the shaft. 150 m northeast at the Copper Shafts, two shallow (7.5-9 metre) shafts were sunk at about the same time (Snelgrove, 1935). The dumps from these shafts have been well picked over by three generations of geologists and rock hounds and little mineralized material from the subsurface remains.

The mineralization presently exposed at the Chetwynd prospect consists mainly of moderately to heavily disseminated pyrite occasionally accompanied by bornite and chalcocite. The host rocks are intensely sheared and altered to a pyrophyllite-sericite-quartz assemblage (Snelgrove, 1935). Occasionally, veins of almost massive bornite up to 2 cm wide parallel the shearing. Reading (1933) reported visible gold from quartz veins around the showing and in panned concentrates from the stream bed. Snelgrove (1935) noted that microscopic gold was seen in a specimen from a quartz vein near the showing and Cooper (1954) later reported the presence of gold in polished sections of several specimens. No previous workers, however, have reported ore grades of gold over significant widths. Accessory minerals seen in outcrop include purple fluorite and barite, which fill vugs and veinlets. Tetrahedrite was reported by both Cooper (1957) and Snelgrove (1935) but was not seen in outcrop during the present investigation. Mineralization encountered underground appears from published reports to have been more impressive; Snelgrove (1935) reported that local men who had worked underground described "lenses of bornite and other sulfides, several feet in thickness... near the bottom of the workings". Likewise, Reading (1933) reported from similar but independent investigations that "lenses of bornite from two to three feet in thickness were found on the 100 foot level, and I was shown immense pieces of chalcopyrite which were said to be from a lens 5 to 7 feet wide, which was exposed in the fifty foot crosscut". Considering the highly leached condition of surface outcrops, it is not surprising that sulfide mineralization appears to be more widespread at depth. The mineralized zone is over 10 m wide in the Chetwynd open cut although copper is

most common in a 2-3 m zone near the centre of the cut. Copper mineralization is known to occur at the Copper Shafts 150 m to the northeast, suggesting that at least this much strike length is well mineralized in the subsurface, and the extensions along strike have not been tested in any manner. The potential for extending the mineralized zones in all directions appears to be excellent, with the possibility of finding significant quantities of copper and/or gold.

The origin of the mineralization is still somewhat enigmatic. The copper minerals are both disseminated and filling veins in surface outcrops, and descriptions of the underground workings suggest this was true at depth as well. The mineralogy of the occurrence (tetrahedrite-bornite-chalcopyrite-gold-fluorite-barite) suggests that the mineralization is epithermal or hypothermal and it is tentatively suggested that mineralization was originally the product of late magmatic events associated with the La Poile Group volcanism. The alteration which accompanies the mineralization is considered to have been contemporaneous although later chemical changes related to metamorphism and deformation have probably occurred. The restriction of the mineralization to the distinctive host horizons suggests that these may be high level granitic sills and the mineralization a product of the outgassing related to their crystallization. Further resolution of this question awaits geochemical and petrographic studies.

The southeast "B horizon" is exposed along approximately 3 km of strike length parallel to and partially overlapping the "A horizon". It reaches a maximum thickness of over 250 m at its northeast end where it is truncated by the Chetwynd Granite. Like the A horizon to the northwest, the B horizon feathers out at its southwest end approximately 800 m southwest of the Chetwynd prospect. The rocks which make up this horizon are more massive and less sheared and altered than those of the A horizon, consisting of buff to cream, aphanitic, cherty-looking rock which is commonly deeply leached and heavily iron stained on the outcrop surface. Occasional faint bluish quartz eyes and white feldspar phenocrysts are visible. This rock has been variously described as "granite porphyry" (Snelgrove, 1935), "siliceous intrusive related to the Roti Granite" (Pouliot, 1957), "silicified and otherwise altered shear zone" (Cooper, 1954), and "altered felsic volcanic bands" (Chorlton, 1978); the nature of the protolith is still in some doubt.

Two showings, the Iron Hat and Hope Brook prospects, have been identified in this horizon. The Iron Hat is a low rocky hill of altered rhyolitic-looking material located approximately 120 m southeast of the Chetwynd shaft. Minor pyrite associated with hematite and tourmaline are present in a 10 m long trench across the southwest end of the outcrop. No base or precious metals have been previously reported and none were seen during the present investigation. The Hope Brook prospect occurs in the canyon of Hope Brook approximately 1.9 km northeast of the Chetwynd shaft. Here, the brook has cut a gorge approximately 15 m deep into the bedrock and the B horizon is well exposed in the third dimension. The altered felsic rock is exposed across approximately 250 m in the canyon bottom and walls. Phenocrysts of quartz and feldspar are common and the rock is impregnated with pyrite, disseminated and concentrated along cleavage planes and fracture surfaces in amounts ranging from 3 to 7%. A little chalcopyrite was seen at one locality. Previous workers report no gold or base metals at this locality and, with the exception of the above mentioned chalcopyrite, none were seen during the present program. The rocks in surface outcrops above the gorge, while being heavily iron stained, contain little or no pyrite and are in all respects similar to those exposed along the entire strike length of this horizon. It

is significant that the only two sulfide localities in the horizon are also the only two places were the unleached subsurface rocks have been exposed - by trenching at Iron Hat and by the stream-cut at Hope Brook - and it seems likely that, in the subsurface, similar amounts of pyrite may be present along the entire 3 km of strike length. The origin of the mineralization is uncertain, but its proximity to the A horizon and similarity of their host rocks, alteration and geologic setting suggest a common genesis with the copper-gold mineralization at Chetwynd. It seems possible that base and precious metal concentrations may also be present in the B horizon, and their surface expression obscured by the extensive outcrop leaching which has taken place.

The only other showing of any consequence in this area is the Woodmans Droke prospect, located approximately 1.2 km west of Cinq Cerf Bay. This prospect was discovered at about the same time as the Chetwynd and received minor attention, including trenching, shortly after its discovery. The mineralization consists of sparse patches of coarse pyrite, chalcopyrite and sphalerite in anastomosing, flat-lying quartz lentils and veins. Galena has been reported from the prospect (Cooper, 1954; Chorlton, personal communication). Host to the veins is sheared, silicic tuff which occupies a somewhat higher stratigraphic position than the showings on Cinq Cerf Brook. This showing is of limited extent and probably of no economic importance.

The only evidence of possible volcanogenic mineralization in the La Poile Group is found in the Peter Snout map area, where Chorlton (1980) reported massive and disseminated magnetite on a high hill overlooking Grandys Brook. The Georges Brook Formation in this area consists mainly of mafic volcanic rocks and volcanogenic sedimentary rocks with lesser rhyolite and felsic tuff. The volcano-sedimentary package is much attenuated here compared to the Cinq Cerf Brook area; it is bounded to the north by the Bay d'Est Fault and to the south by a later intrusion of megacrystic biotite granite.

The magnetite-rich horizon is approximately 10 m thick, appears to strike approximately east-west, and is exposed for approximately 80 m along strike. It is bounded to the south by fine grained felsic rocks which are either felsic volcanics or fine grained phases of the Roti Granite and to the north by medium to coarse grained volcanically derived conglomerate. It is closely associated as well with a distinctive cordierite - andalusite meta-argillite which carries significant amounts of apatite and tourmaline, providing evidence of at least one period of magnesium metasomatism. The magnetite is associated with dark gray, silicic rock which may be chert and appears to be a magnetite iron formation.

On the west side of the same hill, an extensive zone of alteration characterized by chloritization, sericitization, silicification and introduction of pyrite is present. Any relationship between this alteration and the magnetite iron formation 500 m to the east has been obscured by intense deformation. However, the close association of this type of alteration with iron formation coupled with evidence of magnesium metasomatism and coarse volcanic conglomerate may indicate a relatively favorable environment for volcanogenic mineralization. The presence of magnetite rather than iron sulfides may, of course, mean that, in this locality at least, the depositional environment was not sufficiently reducing to have produced economically interesting deposits.

In this same area, the Bay d'Est Fault zone is mineralized along the approximately 12 km of strike length examined. Examination of the fault zone

was prompted by the discovery of sulfides in outcrop by Smyth (1979) and Chorlton (1980). Rocks of the fault zone are well exposed in the beds of streams which in this area flow in the trace of the fault. The rocks appear to be generally volcanogenic, are intensely sheared and altered, and appear to be derived from both the La Poile and Bay du Nord Groups. Widespread injection of pink pegmatite and aplite dikes, which commonly carry abundant tourmaline and, locally, minor sulfides, is found in the fault zone. Pyrite is concentrated at a number of localities where the host rocks are abnormally silicified and sheared. It is commonly disseminated in quantities up to 15% but generally less than 7%. A few specks of chalcopyrite were also noted at one location. The fact that this type of mineralization occurs exclusively within the fault zone seems to suggest that it is probably related to the fault rather than to the host rocks. The mineralization is closely associated with intensely silicified zones and the intense shearing may make it impossible to tell whether the sulfides were originally introduced prior to the shearing. The sulfides in this part of the Bay d'Est Fault zone may be genetically related to the fault, having been introduced during late movement and magmatic/hydrothermal activity in the fault zone. Alternatively, they may represent a prior concentration which has been remobilized by later activity in the fault zone.

MINERALIZATION IN THE BAY DU NORD GROUP

Base and precious metal mineralization has been known in the Bay du Nord Group since 1936 when Alex Strickland discovered the lead-zinc-silver showing which now bears his name on the highlands above La Poile Bay. Subsequent prospecting uncovered a number of sulfide occurrences along strike from the Strickland prospect for approximately 10 km (Cooper, 1954) between Carrot Brook and Big Pond Brook (Figure 3).

The most promising of these showings in the Bay du Nord Group remains the Strickland prospect. The nature of the deposits and summaries of previous work have been presented in some detail by Cooper (1954), Stackhouse (1976) and Chorlton (1978), and the deposit is the subject of an M.Sc. dissertation in progress at Memorial University by J. Wynn. The property on which the showings occur is a fee simple mining grant presently under exploration by Falconbridge Nickel Mines Ltd.

The principal economic mineralization at the Strickland prospect comprises conformable, massive sphalerite and galena; it is commonly argentiferous and occurs at the contact between a laterally extensive felsic pyroclastic unit to the southeast and laminated metasiltstones and phyllite to the northwest. The mineralized horizon strikes approximately 025°-035° Azimuth and dips at 55°-60° to the southeast. Cooper (1954) reported that, in addition, minor amounts of arsenopyrite, pyrite, tetrahedrite, chalcopyrite and native gold are present. The massive mineralization is spacially associated with strongly silicified and sericitized felsic volcanic rocks which range from fine grained tuff to coarse volcanic breccia and it commonly contains fragments of these felsic rocks. Pods of carbonate are closely associated with the mineralization. Cooper (1954) noted that lead-zinc-silver mineralization could be traced in trenches along a strike length of 500 m and that although the thickest exposure of massive mineralization seen on surface was 3.2 m it appeared to pinch out and swell considerably within short distances. Assays of the massive ore reported by Cooper (1954) contain expected good grades of lead and zinc and, in addition, show silver values ranging from 85 to 920 g/t and trace amounts of gold.

Approximately 540 m southwest of the massive lead-zinc-silver mineralization, a zone of intense chloritization and

LEGEND

DEVONIAN (?)

6 **LA POILE BATHOLITH:** Porphyritic granodiorite

ORDOVICIAN

BAY DU NORD GROUP

5 **BAGGS HILL GRANITE:** Equigranular granite, granophyre

4 **DOLMAN FORMATION:** Dominantly felsic metavolcanic rocks, lesser metasediments

3 **PIGLET BROOK RHYOLITE:** Massive pink to cream rhyolite

2 **UNDIVIDED STRATIFIED ROCKS:** 2A, mixed metavolcanics and metasediments, metavolcanics are dominantly felsic pyroclastics; 2B, mainly felsic pyroclastic rocks; 2c, mainly metasedimentary rocks.

1 Metagabbro

MINERAL OCCURRENCES

A - Strickland Prospect: Pb-Zn-Ag-Cu

B - Carrot Brook: Pb-Zn-Py ($\pm$ Cu)

C - Carrot Brook South (2 occurrences)

D - Big Pond Brook (2 occurrences) Cu, Py

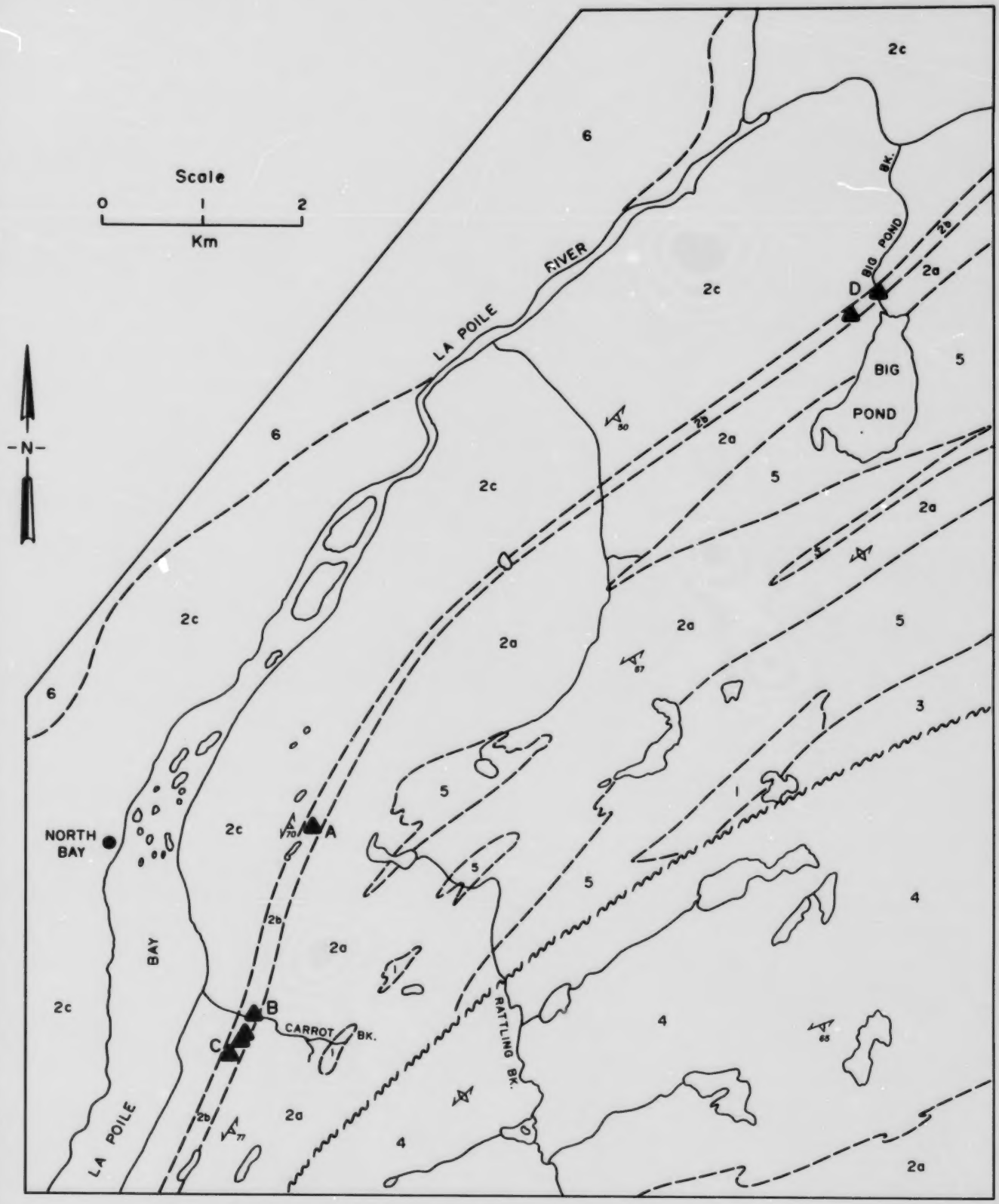


Figure 3. Geology and mineral deposits of the La Poile Group northeast of La Poile Bay

silicification carries minor amounts of chalcopyrite accompanied by pyrite and pyrrhotite as disseminated grains and in stringers. Minor galena and sphalerite are also present. Assays from this zone reported by Cooper (1954) range from 1.6 to 2.8% Cu, although judging from surface exposures, these figures are probably somewhat higher than average grades. One sample carried 170 g/t silver but the rest carried none; likewise, no gold was detected.

Mineralization at the Strickland prospect is almost certainly volcanogenic in origin. The massive lead-zinc-silver mineralization is clearly stratabound and predates deformation of the Bay du Nord Group. The bedding immediately northwest of the sulfide horizon has clearly been transposed and there is no conclusive direct evidence as to the younging direction of strata which host the deposit. By analogy with massive sulfide deposits in other areas, however, one might expect the mineralization to occur at the top of the volcanic pile and be overlain by clastic sediments. Further, in other similar deposits, chloritic, silicic, pyritiferous and cupriferous alteration closely associated with the massive sulfides commonly occurs in the footwall, having resulted from hydrothermal activity related to the mineralizing event. These lines of reasoning coupled with the presence in the massive sulfides of felsic volcanic fragments similar to those outcropping immediately to the southeast, suggest that the Strickland deposit is now overturned and faces to the northwest. A relatively proximal mineralizing environment is suggested by the presence of nearby, relatively coarse, pyroclastic rocks and subvolcanic granites as well as chloritic, cupriferous alteration in the footwall. Rhyolitic fragments in the massive ore are similar to altered felsic rocks in the footwall and may represent pyroclastic debris of nearby explosive activity. Alternatively, they may represent slumped fragments, suggesting that the massive ore has been transported (slumped) from its site of deposition.

There are a number of smaller sulfide occurrences along strike from the Strickland both to the southwest and to the northeast. Approximately 2 km to the southwest, sulfides are present in altered rhyolitic rocks in the bed of Carrot Brook. The best exposures are in an old trench where extensive iron staining signals the presence of pyrite accompanied by minor galena and sphalerite. The sulfides occur as blebs and stringers in the rock and their location appears to be fracture controlled. The host rocks are rhyolites which lie on strike with the felsic horizon that forms the footwall of the Strickland deposit.

On the hills south of Carrot Brook, and at about the same stratigraphic horizon, several old trenches have exposed minor sulfide mineralization along a strike length of approximately 350 m. The host rocks are silicified felsic tuffs which are commonly highly iron stained and which carry minor disseminated pyrite. Quartz veins cut the mineralized rock and some sulfides have been remobilized into these veins. Cooper (1954) reported minor chalcopyrite from one of the trenches.

Approximately 6 km northeast of the Strickland prospect in the bed of Big Pond Brook, up to 5% disseminated pyrite plus chalcopyrite are found in silicified felsic tuff. The heavily mineralized zone is 2-3 m wide although alteration and sparse, disseminated pyrite are present over considerably greater widths. The host rocks appear to be the northeastward extension of the felsic volcanics forming the footwall to the Strickland deposit. Cooper (1954) reported that minor tetrahedrite, pyrrhotite and marcasite are also present. Minor disseminated pyrite and chalcopyrite are locally present along strike to the southwest of Big Pond Brook and Cooper (1954) reported a little sphalerite and galena from one locality in this area.

The sulfide occurrences in the Carrot Brook and Big Pond Brook areas are unlikely to be of economic significance in their own right. However, it is significant that virtually all of the volcanogenic mineralization in the Bay du Nord Group is restricted to a single felsic volcanic horizon and that this horizon forms the footwall to massive stratabound Pb-Zn-Ag mineralization at the Strickland prospect. It is likely that the ore-forming process which resulted in formation of the Strickland deposit (*i.e.* hydrothermal activity related to volcanism) was also responsible for the mineralization seen along strike. These minor occurrences, hosted by hydrothermally altered rocks at a single stratigraphic level, therefore signal the existence of fairly widespread hydrothermal activity during this stage of volcanism. It is not inconceivable that this activity, in the presence of favorable hydrodynamic and physicochemical environments, might have formed further, as yet undiscovered, massive sulfide deposits.

MINERALIZATION IN THE KEEPINGS GNEISS

Several pyritic sulfide occurrences have been previously reported in the Keepings Gneiss and the Northern Granite in the area of Morg Keepings Brook and Prospectors Pond (Douglas and Hsu, 1976), and Cooper (1954) reported discovery of widespread base metal-bearing float in south-flowing streams that drain this terrain. The mineralization described by Cooper (1954) was associated with quartz veins and one sample ran 5.86% Zn and 27 ppm Ag with minor Pb, Cu and Au. A brief examination was made of the Morg Keepings Brook watershed and the area west of Prospectors Pond to check the previously reported mineral occurrences and to determine whether they might indicate a potential for further base metal mineralization in this unit.

Several minor indications of sulfide mineralization were seen in Morg Keepings Brook; all consist mainly of disseminated pyrite with scattered specks of chalcopyrite and galena in quartz segregations in paragneisses. The Prospectors Pond occurrence comprises disseminated pyrite in a deeply weathered and altered granite (Northern Granite) and contains no base metals visible in hand specimen. Nothing seen during this investigation would suggest a potential for economic mineralization in this unit.

REGIONAL CONSIDERATIONS

The ages of the Bay du Nord and La Poile Groups are not known with any degree of certainty as, to date, no fossils have been discovered in these sequences. They are generally considered to be Middle Ordovician on the basis of radiometric dates previously cited; however, these data allow an age as old as Arenigian (Lower Ordovician) if one uses the van Eysinga (1975) time scale and as young as Wenlockian (Middle Silurian) if one uses the Ross *et al.* (1978) time scale. Clearly, temporal correlations of fossiliferous strata elsewhere in Newfoundland with rocks in southwestern Newfoundland dated by radiometric methods must be tenuous at best.

Smyth (1980) has shown that the volcano-sedimentary sequences of southwestern Newfoundland can be traced for a considerable distance around the Hermitage Flexure. Although the area east of Grandys Brook has not yet been mapped at a scale of 1:50,000, his compilations based on available company maps and limited field checking suggest that they outcrop continuously as far east as the Salmon River in the Dolland Brook (11P/15) map area. In this area, they are on strike with the western extension of the Baie d'Espoir Group west of Facheux Bay (Swinden, 1980) and separated from it by approximately 20 km of granite (Figure 1). It seems likely that prior to the granite intrusion, the Baie d'Espoir Group and the eastward equivalents of the Bay du Nord/La Poile Groups were continuous and it may be that volcanic rocks in the Isle Galet Formation of the Bay d'Espoir Group (Swinden, 1980) represent a distal

facies of the relatively more proximal volcanism which is widespread in southwestern Newfoundland. This correlation is supported by the similarity of the volcanic rocks in the two sequences. In both areas, volcanic rocks consist dominantly of laterally extensive, felsic rocks and, in both cases, mafic flows form a minor part of the sequence occurring in the lower stratigraphic levels. Mineralization in the two sequences is likewise similar. The Strickland prospect and the Barasway de Cerf prospect in Bay d'Espoir (Swinden, 1980) are similar in mineralogy, host rocks and general geologic setting. Their differences (*e.g.* larger size of Strickland, lack of footwall alteration at Barasway de Cerf) are features which may be attributed to the relatively more proximal environment occupied by the former deposit. If more deposits should be discovered along strike from Barasway de Cerf in more proximal environments of the Bay d'Espoir Group, they could be expected to look very much like the Strickland. According to Smyth (1979, 1980), the volcano-sedimentary rocks between Grandys Brook and Salmon River are dominantly sedimentary with lesser volcanic material; however, pockets of felsic volcanics are present along the entire belt. As part of a sequence which has a demonstrated potential for volcanogenic Pb-Zn-Ag deposits in both the La Poile Bay and Bay d'Espoir areas, these rocks must be considered as potentially favorable hosts for further similar deposits. Detailed mapping is needed in this area to fully evaluate this potential.

ACKNOWLEDGEMENTS

Richard Lushman provided cheerful and capable assistance during the field season. Discussions with Lesley Chorlton and Ron Smyth, both in and out of the field, provided many valuable insights into the geology of southwestern Newfoundland. Neil Briggs and the Newfoundland staff of Falconbridge Nickel Mines Ltd. provided much useful information and discussion on the geology of the Bay du Nord Group in general and the Strickland prospect in particular. The manuscript has benefited from critical reading by Lesley Chorlton, Baxter Kean and Ron Smyth.

REFERENCES

Anon

1980: Geochronology report, Newfoundland and Labrador. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 143-146.

Cooper, J.R.

1954: The La Poile - Cinq Cerf map area, Newfoundland. Geological Survey of Canada, Memoir 256, 62 pages.

Chorlton, L.

1978: The geology of the La Poile map area (110/9), Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 78-5, 14 pages.

1979a: La Poile River map area (110/16), Newfoundland. *In* Report of Activities for 1978. *Edited by* R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 79-1, pages 45-53.

1979b: La Poile River. Newfoundland Department of Mines and Energy, Mineral Development Division, Map 79-124.

1980: Notes on the geology of Peter Snout (11P/13, west half), Newfoundland, and accompanying map 80201. Newfoundland Department of Mines and Energy, Mineral Development Division, map with marginal notes.

in press: Geology of the La Poile River map area (110/16), Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report.

Dorf, E. and Cooper J.R.
1943: Early Devonian plant fossils from Newfoundland. Journal of Paleontology, Volume 17, pages 264-270.

Douglas, G.V., Williams, D. and Rove, O.N.
1940: Copper deposits of Newfoundland. Newfoundland Geological Survey, Bulletin 20.

Douglas, C. and Hsu, E.
1976: Newfoundland mineral occurrence maps. Newfoundland Department of Mines and Energy, Mineral Development Division, Maps 7625 (Port aux Basques) and 7626 (Burgeo) with tables (Open File Newfoundland 888).

Gillis, J.W.
1972: Geology of the Port aux Basques map area, Newfoundland. Geological Survey of Canada, Paper 71-42, 6 pages.

Pouliot, G.
1957: Geology and mineral deposits of the Cinq Cerf River map area. Unpublished report, Buchans Mining Company, 35 pages.

Reading, A.L.
1933: Unpublished excerpts from a report on the Cinq Cerf Brook mining property to Burgeo Mines Limited, 8 pages.

Riley, G.C.
1959: Burgeo - Ramea, Newfoundland. Geological Survey of Canada, Map 22-1959.

Ross, R.J., Jr., Naeser, C.W., Izett, G.A., Whittington, H.B., Hughes, C.P., Richards, R.B., Zalasiewick, J., Sheldon, P.R., Jenkins, C.J., Locks, L.R.M., Bassett, M.G., Toghill, P., Dean, W.T. and Ingham, J.K.
1978: Fission track dating of Lower Paleozoic volcanic ashes in British stratotypes. Short papers on the Fourth International conference on Geochronology, Isotope Geology, United States Geological Survey, Open File Report 78-7001, pages 363-365.

Smyth, W.R.
1979: Reconnaissance of the Burgeo map area (11P, west half), Newfoundland. *In* Report of Activities for 1978. *Edited by* R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 79-1, pages 54-57.

1980: Reconnaissance geology of the White Bear River (11P/14) and Dolland Brook (11P/15) map areas. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 89-92.

Snelgrove, A.K.
1935: Geology of the gold deposits of Newfoundland. Newfoundland Department of Natural Resources, Geological Section, Bulletin 2, 46 pages.

Swinden, H.S.
1980: Economic geologyy of the eastern Hermitage Flexure. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 100-109.

Van Eysinga, F.S.W.
1975: Geological time table. Elsevier Scientific Publishing Company, Amsterdam, The Netherlands.

GEOLOGY OF WOLF MOUNTAIN (12A/2W) AND BURNT POND (12A/3E), CENTRAL NEWFOUNDLAND

by

W.L. Dickson and H.E. MacLellan

INTRODUCTION

The Wolf Mountain (12A/2W) and Burnt Pond (12A/3E) map areas are located in south-central Newfoundland approximately 60 km south of Buchans. Access to Granite Lake, a prominent lake in the northern part of the the map area, is by a recently constructed but deteriorating gravel road. This road is an extension of a much older woods road from Millertown and was constructed during the building of dams and ditches for the Bay d'Espoir hydroelectric project in the mid sixties. Dam construction has resulted in flooding of large parts of the map area.

Much of the field area is accessible from this road and from another road which runs along the north bank of the ditch between Granite and Meelpaeg Lakes. Grey River cuts through the eastern half of the map area but is suitable for canoe work only in the spring when water levels are high. Access to the rest of the area is best gained by helicopter as even the largest ponds are shallow and very rocky and, thus, unsuitable for float planes.

The Granite Lake area recently became the target for mineral exploration following lake sediment geochemical studies by Butler and Davenport (1978, 1980) which showed anomalous areas of U, Zn, Mo, and Ag in the northeast part of the map area. Smaller, less anomalous areas of U and Mo occur in the southeast and northwest corners of the map area.

Previous geological mapping in the area is limited. Phendler (1950) examined a belt 5 km wide around Granite Lake prior to flooding and defined the main geological elements. Riley (1957) mapped the west half of the map area as part of 1:250,000 mapping of sheet 12A (west half). Williams (1970) mapped the east half of the map area as part of 1:250,000 mapping of sheet 12A (east half). Smyth (1979) compiled a map of the Burnt Pond sheet (12A/3) using unpublished maps of the Buchans Mining Co. and some reconnaissance mapping.

Exposure in the area is very variable and is generally controlled by rock type. Metasedimentary rocks and mylonitic granites are generally well exposed while more massive granitoid rocks are usually poorly exposed.

The area is covered by an extensive blanket of boulder till and bog with scattered drumlins and eskers. Glacial erratics are very common. Glacial striae are rare but show a southerly direction of ice movement.

GENERAL GEOLOGY

The map area is underlain by a variety of metasedimentary and granitoid rocks. Riley (1957) shows a narrow belt of basic volcanic rocks in the southwest of the map area; however, these were not found during field work (see also Smyth, 1979). The metasediments are tentatively correlated with the Middle Ordovician Bay du Nord Group (Chorlton, 1978) mainly on the basis of lithological similarity. The granitoid rocks form the northwest end of the Devonian North Bay Granite (Jewell, 1939; Colman-Sadd, 1976) and underlie most of the map area. The granitoid rocks are generally weakly deformed but a major mylonite zone cuts the granite and metasediments in the southwest part of the map area.

No fossils were found in the metasediments and no ages have been obtained from this area. Williams, however, reports a K/Ar date of 385 ± 16 Ma from granite 35 km to the northeast of Granite Lake.

DESCRIPTION OF UNITS

The rocks within the map area have been divided into seven units. Units 1 to 3 are metasedimentary and may be metamorphic equivalents. Units 4 to 7 are granitoids which are intrusive into Units 1 to 3.

Unit 1

Unit 1 underlies the north-central part of the map area around Granite Lake. A small embayment of Unit 1 is located at the western boundary of the map area north of Granite Lake. The main rock type in the unit is complexly deformed and migmatized metasediments. The migmatite is composed of a foliated biotite-muscovite tonalite neosome (or mobilizate) and a quartz-biotite-muscovite schist paleosome (or restite).

The paleosome is medium to coarse grained, tightly folded in places, and occurs as parallel layers or angular blocks within the neosome. Apart from rare angular blocks of amphibolite of presumed igneous origin, the paleosome is entirely metasedimentary. This is suggested by alternating layers of quartzite, psammitic schist and pelitic schist. Crossbeds were found in some blocks of quartzite.

The neosome consists of weakly to strongly foliated, medium grained, equigranular granite or granodiorite with minor pegmatite and forms 1 to 30 cm veins which are commonly parallel.

The paleosome is polyphase deformed and metamorphosed and contains two main fabrics. Angular blocks containing the folded schistosity are common as xenoliths in the granite neosome.

The neosome has also been polyphase deformed. This is shown by "Type 1" interference patterns (Ramsey, 1967) where the migmatite forms small isolated basins. Generally, the neosome is moderately schistose.

Towards the southern tip of the migmatite complex around Granite Lake, there is a heterogeneous zone of migmatite, schist and weakly deformed diorite to granite dikes. The general sequence of intrusion is from basic to acidic, ending with garnet-muscovite-tourmaline granite pegmatite. Common throughout this mixed zone are veins of tourmaline which cut all other phases.

Unit 2

This unit occurs at the eastern margin of the map area and forms the northwest corner of a long narrow belt of metasediments which outcrops mainly to the east of the map area (see Williams, 1970). The metasediments are mainly medium grained, thinly bedded to laminated, semipelitic to pelitic biotite-muscovite schists. The metasediments have been deformed to produce tight isoclinal folds which plunge gently to the northeast. Unit 2 contains spots of cordierite and biotite that were probably produced by contact metamorphism during emplacement of Unit 7.

Unit 3

Unit 3 outcrops in the southwest portion of the map area and mainly comprises psammite with lesser amounts of semipelite and rare metaconglomerate. They have been variably deformed and metamorphosed. These rocks are medium to thinly bedded with rare parallel laminations, crossbeds, and graded beds. Younging to both northeast and southwest was found. Bedding and cleavage are generally steeply dipping and, locally, slightly overturned. Bedding has been folded into tight isoclinal folds with a steep axial

LEGEND

DEVONIAN(?)

6, 7 *7 Massive to weakly foliated, medium to coarse grained, porphyritic biotite-muscovite granite.*

6 Massive to weakly foliated, coarse grained, porphyritic biotite granite.

5 *Massive to weakly foliated, uniform to sparsely porphyritic, medium grained biotite-muscovite granite.*

4 *Weakly foliated, uniform medium grained, biotite granite and granodiorite.*

ORDOVICIAN(?)

BAY DU NORD GROUP? (1,2,3)

3 *Psammitic biotite schist with minor pelitic schist, slate, and pebbly sandstone.*

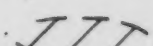
2 *Psammitic and pelitic spotted biotite schist.*

1 *Migmatite and schist, probably derived from 1 and 2; includes abundant granitic dikes south of Granite Lake.*

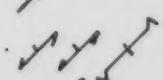
SYMBOLS

Geological boundary (approximate, assumed, gradational) . . . . .

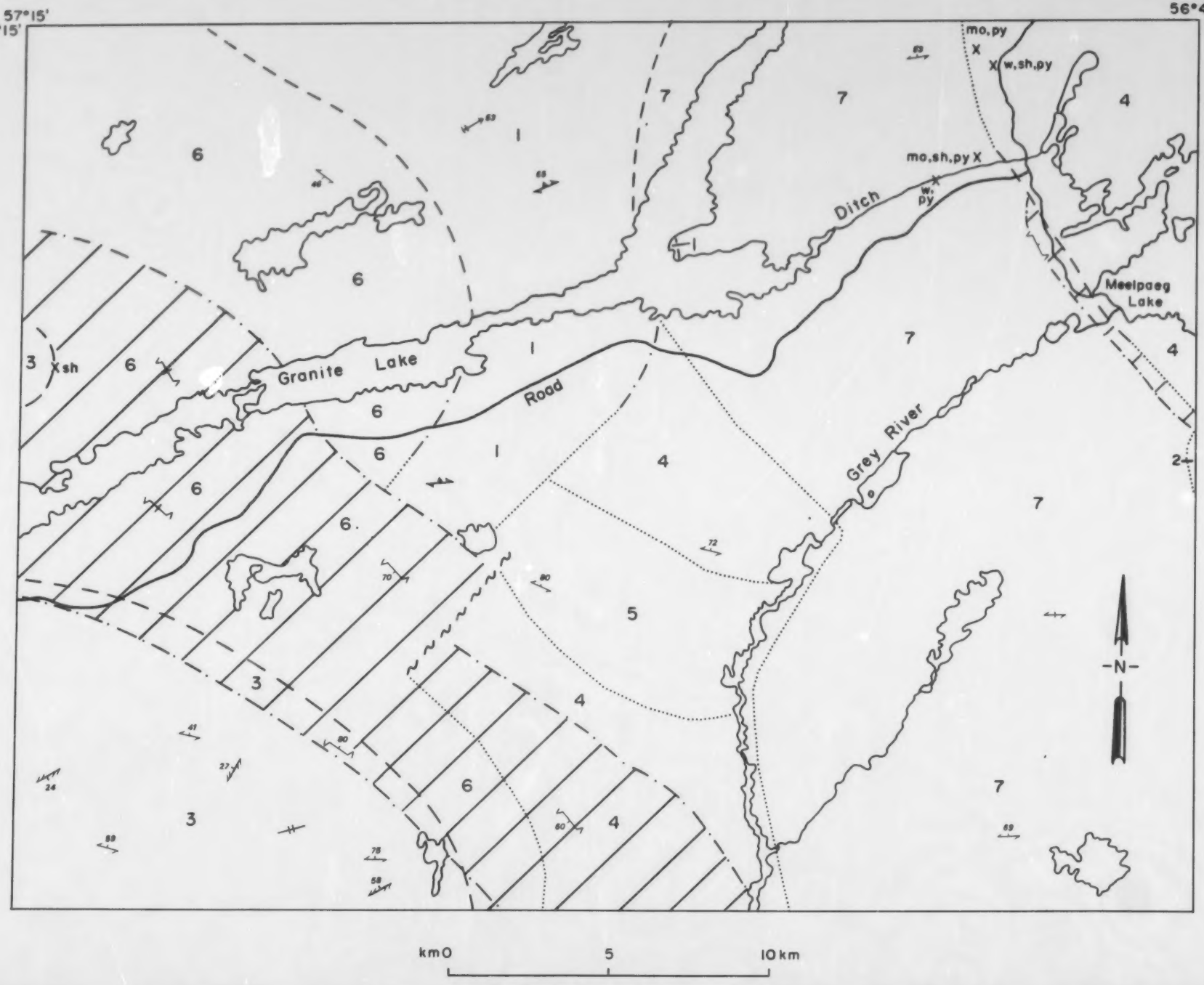
Fault . . . . .

Shear zone . . . . . 

Bedding (tops unknown) . . . . .

Cleavage, foliation, mylonitic foliation . . . . . 

Lineation . . . . .


57°15'
48°15'
56°45'
48°15'
mo,py
X
X w,sh,py
mo,sh,py X
w, py
Ditch
Meelpaeg Lake
Granite Lake
Road
Grey River
X sh
-N-
km 0
5
10 km

99

planar cleavage. A second cleavage has developed in places along large kink bands which have gentle dips. The northeast margin of the unit has been intensely mylonitized with Unit 6. The mylonitic fabric has transposed the main fabric in Unit 3.

Metamorphism of Unit 3 is generally low greenschist facies. However, towards the northeast, the metamorphic grade increases as the granite contact is approached. Towards the southwest corner of the map area, the metamorphic grade increases and spotted biotite-muscovite-garnet schist and hornblende hornfels predominate.

Units 1 to 3 are tentatively correlated on the basis of similar parent rock types and bed forms. The style of folding is comparable with tight similar folds found in all the units. Unit 1, however, appears to be more complexly deformed.

Unit 4

This unit is located in the northeast corner and centre of the map area. The two areas are grouped together because of lithological similarities. The dominant rock type is foliated, medium to fine grained, equigranular, biotite granodiorite. Small amounts of muscovite may be present locally. Xenoliths of migmatite, schists, diabase, and foliated quartz diorite are common in both areas. Unit 4 is cut by Unit 7 near the east end of the ditch and also near the southern end of Grey River.

There are, however, differences between the northeastern and southern areas of Unit 4. The northeastern area has locally well developed, generally steeply dipping layers of biotite-rich and biotite-poor granodiorite. These layers are up to 4 cm thick and are variable in length, but are commonly several metres. This type of layering is absent in the southern region.

Garnet-muscovite pegmatite veins are common and, locally, dikes of coarse grained granite from Unit 7 cut Unit 4. Near the assumed southeast contact with Unit 5, dikes of biotite-muscovite granite similar to Unit 5 cut Unit 4. The northeast section of Unit 4 is cut by mineralized quartz veins which contain molybdenite and wolframite.

Unit 5

Unit 5 outcrops in the centre of the map area and is distinguished from Unit 4 by a significant proportion of muscovite and by lower color index. The rock is mainly a medium grained, weakly foliated, equigranular biotite-muscovite granite. It generally contains about 1% muscovite and 1% to 2% biotite. Scattered xenoliths of quartz diorite are common and the granite is cut by garnetiferous aplite and granite pegmatites.

Unit 6

Unit 6 underlies most of the western half of the map area. The main rock type is pink to gray, medium to coarse grained, weakly foliated, porphyritic, biotite granite. Flow alignment of K-feldspar phenocrysts is locally well developed. Scattered inclusions of strongly foliated granodiorite and quartz diorite, psammitic biotite-muscovite schist, and migmatite are found in Unit 6. Aplite and pegmatite dikes are found throughout the unit.

The southwestern section of Unit 6 together with the northeast margin of Unit 3 have been subjected to intense mylonitization, which has converted the granite and metasediments to mylonite schists. The mylonite zone trends northwestwards and is 5 to 10 km wide. K-feldspar phenocrysts have been variably realigned to form 1 to 2 cm augen. The fabric in the granite is defined by flattened quartz and well aligned biotite and chlorite. Lithic fragments in conglomerates have been flattened to form thin lenses.

Unit 7

Unit 7 underlies most of the eastern portion of the map area. The main rock type in Unit 7 is medium to coarse grained, porphyritic, weakly foliated to massive, biotite-muscovite granite. Locally, the granite shows a very variable texture ranging from aplitic to pegmatitic. The southern region of the unit contains areas of leucocratic, pegmatitic, muscovite granite. The contact between Unit 1 and Unit 7 is intrusive. Coarse grained porphyritic granite dikes cut Unit 1.

A narrow mylonite zone marks the boundary between Units 4 and 7 near Meelpaeg Lake. Unit 7 is intensely flattened to form an augen schist which is faulted against Unit 4, which contains chlorite-filled fractures. This mylonite zone dies out to the northwest and southeast.

Extreme alteration of the granite to epidote and clay minerals is well shown along the walls of the ditch, where numerous northeast trending shear zones cut the granite. Alteration of biotite to sericite is also common around and to the north of the ditch. The alteration is associated with a reddening of the granite and molybdenite-pyrite-fluorite and wolframite mineralization.

MINERALIZATION

Molybdenite

Molybdenite mineralization was discovered by several exploration companies in Unit 7 and Unit 4 in the northeast corner of the map area. Small showings of molybdenite occur along the banks of the ditch in medium grained, porphyritic to equigranular, biotite-muscovite granite of Unit 7. The molybdenite mineralization occurs in quartz veinlets, in pegmatites, in joints as smeared joint "paint", and as disseminations in the granite. Associated minerals are pyrite and fluorite, with minor chalcopyrite in a few places. All showings found along the ditch were small.

Molybdenite mineralization also occurs in the granodiorite of Unit 4 as disseminated minerals in vugs and quartz veins, and also, as smears along joints. The host rock is generally highly fractured. Pyrite is associated with the molybdenite. This occurrence is within an isolated outcrop so the extent of mineralization is not known.

Wolframite and Scheelite

Tungsten mineralization occurs in Unit 7 along the banks of the ditch west of the molybdenite mineralization. Manganese-rich brown wolframite (Higgins, personal communication, 1980) associated with pyrite occurs in small vugs associated with pegmatite. The wolframite crystals are 1 to 2 mm long and line the cavities. Ultraviolet fluorescence of samples taken along the ditch shows that small amounts of probable disseminated scheelite are common.

Coarse pegmatitic wolframite with associated scheelite and pyrite occur within a quartz vein which cuts Unit 4 near the northeast corner of the map area. The main quartz vein is approximately 1 m wide and is discordant to the main tectonic fabric in the host biotite granodiorite. The vein has a sheeted appearance which is partly due to multiple injections of quartz and also to shearing parallel to the quartz layers. Minor wolframite mineralization also occurs in leucocratic granite dikes and segregations within the foliated granodiorite of Unit 4. Scheelite associated with pyrite also occurs in quartz veinlets in this area.

UV fluorescence of a sample of strongly mylonitized granite from the western part of the field area shows possible finely disseminated scheelite.

SPECTROMETER SURVEY

No areas of anomalous radiation were found. Granitoid rocks gave readings on a Scintrex GIS-4 gamma ray spectrometer of approximately 100 to 250 counts per second. Metasediments gave readings of generally less than 100 counts per second.

Future work on the project will include detailed analysis of thin sections and polished sections. 45 granite samples were collected for geochemistry. These will be analzsed for major and trace elements, including Mo, U, F, Li, Be, W, Cu, Pb, Ag and Zn.

ACKNOWLEDGEMENTS

The authors thank Andre Barry, Barry Wheaton and Carl Wheaton for their assistance during the field work. The logistical support of James Barrett, Sydney Parsons, and Wayne Ryder was greatly appreciated. Viking Helicopters provided excellent helicopter service. Neville Higgins of Memorial University is thanked for identification of the manganiferous wolframite. N.R. Jayasinghe, B.F. Kean and W.R. Smyth are thanked for critically reading the manuscript.

REFERENCES

Butler, A.J., and Davenport, P.H.
1978: A lake sediment geochemical survey of the Meelpaeg Lake area, Central Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Open File Nfld. 986.

Butler, A.J. and Davenport, P.H.
1980: Lake sediment geochemistry, Red Indian Lake area, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Open File Nfld. 12A(249).

Chorlton, L.B.
1978: La Poile River map area (110/16), Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Map 78168, with marginal notes.

Colman-Sadd, S.P.
1976: Geology of the St. Alban's map area, Newfoundland (1M/13). Newfoundland Department of Mines and Energy, Mineral Development Divsion, Report 76-4.

Jewell, W.B.
1939: Geology and mineral deposits of the Baie d'Espoir area. Geological Survey of Newfoundland, Bulletin 17, 29 pages.

Phendler, R.W.
1950: Geology of the Granite Lake area. Private report, Buchans Mining Co.

Ramsey, J.G.
1967: Folding and fracturing of rocks. McGraw-Hill Book Company, New York. 568 pages.

Riley, G.C.
1957: Red Indian Lake (west half). Geological Survey of Canada, Map 8-1957.

Smyth, W.R.
1979: Burnt Pond. Newfoundland Department of Mines and Energy, Mineral Development Division, Map 7955.

Williams, H.
1970: Red Indian Lake (east half), Newfoundalnd. Geological Survey of Canada, Map 1196A.

THE GEOLOGY OF THE GRAND LAKE AREA, LABRADOR
13F/10, 11, 14, 15

by

Bruce Ryan, Tim Neale[1], Jeryl McGuire[2]

Regional geological mapping at 1:100,000 scale was conducted in the Grenville Structural Province in the vicinity of Grand Lake during the 1980 season. Previous mapping in the study area has been minimal, being confined to the early reconnaissance work of Scott and Conn (1949) and the 1:250,000 mapping by the Geological Survey of Canada (Stevenson, 1967). Hudbay Uranium carried out a uranium exploration program in the area in 1977 (Fenton, 1978), but no new lithological data were made available by this survey. Preliminary reconnaissance work carried out in the northern part of the area by the author in 1979 (Ryan, 1980) indicated that much of the terrain shown by Stevenson (1967) as chiefly "black and white gneisses and gneissic granite of probably sedimentary origin" could be subdivided into several major units. Many of the rocks were found to be very weakly foliated granitoids with no indication of a sedimentary protolith such as was suggested by Stevenson (1967). The granitoids were separated from the apparently earlier gneissic rocks, and it was suggested that the area contained elements which may range from Archean to Helikian in age. This year's work has refined last year's initial results north of Grand Lake, and has provided new data for the area south of the Susan River - Grand Lake corridor. Figure 1 is a generalized sketch map of the coverage area; some brief attributes of the units are outlined below.

The area may be divided into autochthonous and allochthonous elements, the primary relationship between which is uncertain. Units 1-11 are considered to be autochthonous, whereas Unit 12 and Units 13-16 represent two overlying thrust sheets. Relative and absolute ages of rock units are in many cases unknown.

AUTOCHTHONOUS ROCKS

Unit 1 - Foliated tonalite, tonalitic gneiss, migmatite

Gray weathering, foliated, porphyritic tonalite and well-layered tonalitic to quartz dioritic gneisses outcrop between Grand Lake and the Cape Caribou River. Zoned plagioclase phenocrysts and pale green clinopyroxene are present in the weakly foliated portions of the unit but, for the most part, the unit is strongly foliated to gneissic, with quartz, feldspars, biotite and hornblende being the chief phases.

Several thin garnetiferous amphibolite bands were noted in the unit. These occasionally exhibit a relict gabbroic texture and may have been dikes. However, they are pretectonic, exhibiting all the deformation features seen in the surrounding gneiss. Clinopyroxene and scapolite are present in some of these amphibolites.

North of Grand Lake, there occurs a series of similar gneisses which exhibit a pervasive migmatization attributed to the Grenvillian Orogeny. These are characterized by a network of quartzo-feldspathic veins, containing stubby hornblende and garnet porphyroblasts, which parallel and crosscut the gneissic layering and commonly exhibit diffuse contacts with the surrounding rocks. It is unclear at present whether these

1 1788 Keloka Place, Kelowna, B.C.
2 81 McDonell Av., Toronto, Ont.

LEGEND

ELSONIAN
16 Granite, monzonite, syenite.
15 Anorthosite
14 Gabbro

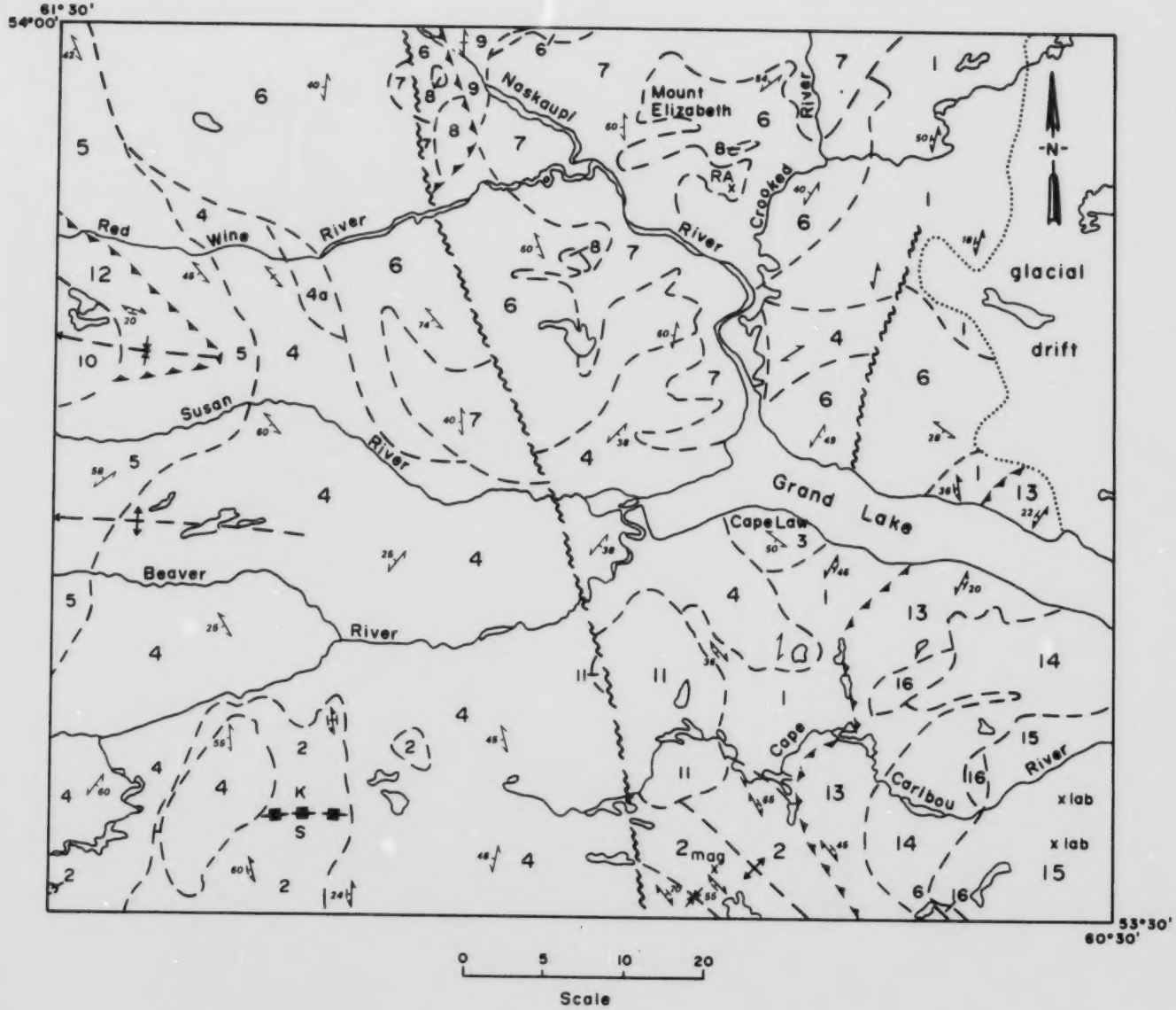
APHEBIAN OR EARLIER
13 Quartzofeldspathic gneiss and amphibolite.
----------THRUST CONTACT----------

APHEBIAN ?
12 Quartzofeldspathic gneiss, amphibolite, gray quartzite.
----------THRUST CONTACT----------

NEOHELIKIAN (AND LATER?)
11 Gabbro, syenite, granite.
10 Diorite
9 Sericitic white quartzite (Seal Lake Group)

PALEOHELIKIAN
8 Gabbro
7 Aplite
6 Biotite monzonite and granodiorite
5 Megacrystic granodiorite
4 Biotite & hornblende tonalite; 4a garnetiferous diorite.

APHEBIAN OR EARLIER
3 Garnetiferous leucogabbro
2 Sillimanite and kyanite bearing biotite-muscovite-quartz-feldspar gneiss.
1 Tonalite, tonalitic and quartz dioritic gneiss, amphibolite.


61° 30'
54°00'
Naskaupi
River
Mount
Elizabeth
RA
Crooked
River
Red
Wine
River
4a
Susan
River
Beaver
River
Grand
Lake
Cape Lay
Cape
Carlbou
River
glacial
drift
x lab
x lab
2mag
K
S
N
53°30'
60°30'
0
5
10
20
Scale

migmatites were derived from the gneisses of the Cape Caribou River area or whether they may be migmatitic and gneissose equivalents of some of the other rocks in the area. They are tentatively correlated with Unit 1, but this is open to reinterpretation pending future work.

Unit 2 - Kyanite and sillimanite bearing gneiss

Rocks of assumed metasedimentary origin are interleaved with Unit 1 south of the Cape Caribou River, and occur as rafts in a younger granitic pluton south of the Beaver River. The annular one records a kyanite to sillimanite transition from north to south. The metasedimentary rocks vary from granoblastic with a weak mica foliation to well layered gneisses. The most widespread mineral assemblage is quartz-feldspar-garnet-biotite with either sillimanite or kyanite. Muscovite is widespread in the kyanite zone, but is less common in the sillimanite zone. Textural relationships suggest that kyanite is later than sillimanite and thus records an increase in pressure to the north. Thin amphibolite units are also locally present in the metasediments, but no marbles or quartzites such as those described by Gower (this volume) were observed.

Dikes and sheets of foliated pink granite are present locally, as are posttectonic quartzofeldspathic pegmatites with books of muscovite and biotite up to 10 cm in diameter. One small plug of serpentinized ultramafic rock exhibiting a discordant contact with the gneisses was also observed south of the Beaver River.

Unit 3 - Garnetiferous leucodiorite

This unit underlies Cape Law on the south shore of Grand Lake. It is a medium grained rock which locally displays a compositional layering interpreted to be a primary feature. Its chief minerals are hornblende, garnet, plagioclase and biotite with locally abundant scapolite. The relationship of this rock to the previously described gneisses is uncertain. It is mineralogically similar to and may be the equivalent of banded diorites along the Red Wine River interpreted as a marginal phase of Unit 4 but, pending future work, the Cape Law rocks are designated separately.

Unit 4 - Tonalite and quartz diorite

This unit occupies a major portion of the area between the Susan River and the southern margin of the map area. It is a gray and white weathering rock but, in border zones, it is pinkish weathering. Texturally, it varies from massive to gneissose. It is locally porphyritic, especially where it outcrops in the core of the metasediments south of the Beaver River. Hornblende $\pm$ biotite, plagioclase, quartz and scapolite are the chief minerals, but microcline is present locally.

As noted from the 1979 survey (Ryan, 1980), the tonalite is locally characterized by anatectic melts which occupy dilation fractures and parallel the foliation, thus imparting a migmatitic character to the rock. This migmatization is identical to that observed in gneissic rocks north of Grand Lake which are tentatively correlated with Unit 1.

Narrow dioritic marginal zones are present adjacent to the eastern boundary of the annular metasedimentary unit. A more extensive unit of massive to banded gray to black, medium to fine grained, garnetiferous diorite outcrops north and south of the Red Wine River. It comprises hornblende-plagioclase-garnet rocks similar to Unit 3.

Unit 5 - Megacrystic granodiorite

Very coarse grained megacrystic granodiorite outcrops along the western margin of the map area between the Susan

and Beaver Rivers; it corresponds to the "porphyritic veined augen gneiss" of Stevenson (1967). This granitic body is composed of pink, twinned microcline megacrysts and recrystallized megacrysts up to several centimetres in maximum dimension set in a medium grained matrix of quartz, feldspar and biotite. In several outcrops, hornblende was observed as a matrix phase accompanied by small red garnets. Lensoid basic inclusions occur locally. This granite varies from undeformed to augen textured to strongly schistose.

Unit 6 - Monzonite and granodiorite

This unit comprises white to pink weathering, medium to coarse grained, biotite-rich granitoid rocks which are the southern extension of a lithologically similar suite dated at 1500 Ma which intrudes the volcanic rocks of the Central Mineral Belt to the north (Ryan and Harris, 1978). These rocks vary from undeformed to strongly schistose. Textures in undeformed areas vary from equigranular to porphyritic to "blebby", the latter referring to a texture in which the biotite occurs as clots or clumps in a leucocratic matrix. Igneous layering was noted in this suite in the Mount Elizabeth area, the layering being defined by variations in the percentage of mafic minerals. These rocks commonly display a mottled greenish weathering appearance due to the development of epidote after biotite and the saussuritization of the plagioclase. Locally, these also exhibit an *in situ* migmatization.

Unit 7 - Leucocratic microgranite, aplite

Pink to white weathering, medium to fine grained, saccharoidal, leucocratic microgranite and aplite dikes and sheets transect all rocks in the area, and are no doubt of various ages. In most cases, these are too small to map at the present scale, but such rocks underlie a fairly extensive area in the vicinity of Mount Elizabeth, where they intrude the coarse granodiorites and monzonites of Unit 6. Border zones are characterized by complex sheeting and interfingering contacts with the surrounding rocks. Texturally, they vary from massive to gneissose, and were apparently misinterpreted as arkosic metasediments by Stevenson (1967). Although biotite is the chief mica in these rocks, muscovite is also widely distributed in some phases. Garnet and hornblende also occur locally.

Unit 8 - Gabbroic rocks

Gabbroic rocks intrude Units 6, 7 and 8. They underlie Mt. Sawyer, a prominent, flat mountain north of the Red Wine River, where they are greenish gray weathering, medium grained, subophitic textured rocks in which the pyroxene commonly is rimmed by pale green amphibole. A bald hill south of the confluence of the Red Wine and Naskaupi Rivers is underlain by brown weathering, cumulate textured, gabbroic rocks and layered ultramafics. The latter were previously interpreted as andesitic volcanic rocks by Stevenson (1967). It is unclear whether these gabbroic rocks should be correlated with the Michael Gabbro dikes which outcrop extensively in the area to the north and east (Greene, 1972) or with the Elsonian anorthosite suite.

Unit 9 - Sericitic white quartzite (Seal Lake Group)

White and gray, sericitic quartzite of the Bessie Lake Formation of the Seal Lake Group occurs as a septum in the north-central part of the area, where it has been overidden by a thrust sheet of Units 6, 7, and 8. The eastern contact is assumed to be an unconformity, but it is not exposed.

Unit 10 - Pyroxene gabbro

A massive to very weakly foliated, gray-green weathering, medium to fine grained, two pyroxene gabbro outcrops between the Red Wine and Susan Rivers.

It comprises plagioclase, clinopyroxene, orthopyroxene, biotite and hornblende. From the outcrop distribution in the area, the unit could be interpreted to intrude a Grenvillian thrust and, thus, may be of post-Helikian age. However, exposure is too poor to demonstrate this interpretation. The lithological similarity to Unit 11 and rocks associated with the anorthosite suite suggests that an Elsonian age is probably more likely.

Unit 11 - Gabbro, syenite, granite

A large composite plutonic body comprising gray weathering gabbro and pink to white weathering syenite and alkali feldspar granite occurs south of the west end of Grand Lake. These rocks are commonly orange or rusty on freshly broken surfaces. For the most part, the rocks are medium grained, but fine grained phases do occur. Most of the unit is massive, but a foliation is developed along its margins. A granular texture indicates recrystallization during metamorphism. The gabbroic members of the intrusion are composed of plagioclase, diopside, hypersthene, and perthite, with accessory (secondary) hornblende, biotite and garnet; garnet coronas are developed on the mafic constituents. Stevenson (1967) considered these rocks as closely related to the anorthosite series.

ALLOCHTHONOUS ROCKS

Unit 12 - Mylonitized granitic and supracrustal rocks

An openly folded thrust sheet comprising pink and white weathering, mylonitized granitoids, garnetiferous, gray weathering semipelitic gneiss, garnetiferous amphibolite and gray quartzite occurs south of the Red Wine River. The contact with the megacrystic granite may be a remobilized intrusive one.

Unit 13 - Gray gneiss, amphibolite, mylonite

Gray tonalitic gneisses and amphibolites into which a gabbro/anorthosite suite (Units 14, 15) has intruded outcrop in the vicinity of the Cape Caribou River. This unit is mylonitized at the base of the thrust. The mylonites north of the Cape Caribou River contain orthopyroxene, a feature noted by Bourne (1978) in his discussion of Grenville Province metamorphism. Felsic gneisses from this complex contain a quartz-feldspars-hornblende-plagioclase-clinopyroxene-garnet assemblage with biotite and scapolite present locally.

The mylonites have undergone postkinematic recrystallization, which has eradicated much of the mylonitic microstructure.

Unit 14 - Gabbro, diorite

Massive to well layered leucrocratic to melanocratic metagabbro and metadiorite intrude the gneisses of Unit 13. These are usually nonschistose, but locally possess a strong lineation. Garnet is a common component in the metagabbros, and may also occur in the host gneisses adjacent to the contact. This feature is apparently due to aluminum metasomatism during metamorphism. The gabbros tend to be melacratic rocks which grade into ultramafic and leucogabbroic variants. Plagioclase-clinopyroxene-hornblende-garnet$\pm$biotite$\pm$scapolite is a common assemblage but orthopyroxene is present locally; a clinopyroxene-orthopyroxene-olivine-spinel assemblage has been observed in the ultramafics.

Unit 15 - Anorthosite

Medium to coarse grained, gray to white weathering anorthosite and norite occupy the southeast corner of the map

area. Very coarse phases occur locally, containing bronzite crystals up to 50 cm in maximum dimension. The anorthositic rocks are commonly recrystallized and amphibole rims are visible on the pyroxenes in hand specimen.

Unit 16 - Monzonite, syenite and granite

These rocks are similar in all respects to those of Unit 11, to which they are probably equivalent. A strong lineation is commonly present and, locally, a planar fabric is developed.

ECONOMIC GEOLOGY

No major new occurrences of economic mineralization were found, but minor concentrations were noted. These include the presence of restricted seams and disseminations of magnetite in the metasedimentary rocks, the occurrence of anomalous radioactivity plus fluorite and molybdenite in the pink aplites west of the Crooked River (Ryan, 1980), and the localized occurrence of blue labradorite in the least recrystallized parts of the anorthosite.

STRUCTURE AND METAMORPHISM

The area is characterized by a generally north-south trending structural grain which has been affected by later east-west trending open folds. Such northerly trends are strongly discordant to the general trend of the Grenville Structural Province. It appears that this is an early Grenvillian feature, predating the more widespread east-west and northeast trending fabrics commonly associated with the Grenvillian Orogeny.

The emplacement of the thrust sheets is considered to have been a Grenvillian event since it affects rocks of the Elsonian suite. Post-thrusting folding is apparent both on regional scale and in outcrop.

A north-south trending fault transecting the area is the southerly extension of the Pocketknife Lake Fault, a prominent structural break in the area to the north (Smyth *et al.*, 1978).

Metamorphic assemblages vary across the area and are in part compositionally and probably age controlled. For instance, there is no obvious change in the mineralogy of the Unit 4 tonalite corresponding to the kyanite-sillimanite isograd in the metasediments of Unit 2 which it intrudes. This may be due to the fact that the tonalite does not contain index minerals indicative of high grade metamorphism. Alternatively, the metamorphic isograd in the metasediments is a pre-Grenvillian feature. In general, metamorphic mineral assemblages reflect amphibolite facies metamorphism, with the exception of the monzonitic rocks along the northern fringe of the area, which are at greenschist grade. Granulite facies assemblages in the mylonites south of Grand Lake predate the thrusting.

SUMMARY

The map area comprises allochthonous and autochthonous elements, but for the most part relative and absolute ages are unknown. The chronology outlined on the accompanying legend is very tentative. However, it appears that all rocks, with the possible exception of Units 10 and 11, are pre-Seal Lake Group in age, *i.e.* pre-Neohelikian.

Systematic prospecting of the aplitic rocks may produce more indications of radioactivity, and labradorite may be more widely distributed in the anorthosite than indicated by the scale of this survey.

Investigations are continuing on the metamorphism and structure in order to more completely evaluate the character of the Grenvillian Orogeny in this area.

ACKNOWLEDGEMENTS

We would like to thank Bruce Vey, Kevin Brewer, and Kevin Freake for capable field assistance, and Randy Hamlyn for keeping us well fed. The air crews from Versatile Air Services are thanked for very competent helicopter support, and Wayne Tuttle and staff in Goose Bay provided the usual logistical support.

REFERENCES

Bourne, J.H.
1978: Metamorphism in the eastern and southwestern portions of the Grenville Province. *In* Metamorphism in the Canadian Shield, Geological Survey of Canada, Paper 78-1C, 315-328.

Fenton, J.
1978: Final report on project generation, Labrador project area. private report, Hudbay Uranium Ltd.

Greene, B.A.
1972: Geological map of Labrador. Newfoundland Department of Mines, Agriculture and Resources, St. John's.

Ryan, B.
1980: Preliminary reconnaissance study of the northern Grenville province, Naskaupi River area, Labrador. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 147-153.

Ryan, B. Harris, A.
1978: Geology of the Otter-Nipishish-Stipec Lakes area, Labrador (13K/2,3,6,7). *In* Report of Activities for 1977. *Edited by* R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 78-1, pages 51-58.

Scott, H.S. and Conn, H.K.
1949: Geology of the Goose Bay area, Labrador. Photographic Survey Corporation, 70 pages.

Smyth, W.R., Marten, B.E., and Ryan, A.B.
1978: A major Aphebian-Helikian unconformity within the Central Mineral Belt of Labrador: definition of new groups and metallogenic implications. Canadian Journal of Earth Sciences, volume 15, pages 1954-1966.

Stevenson, I.M.
1967: Goose Bay map area (13F). Geological Survey of Canada, Paper 67-33.

GEOLOGY OF THE RED WINE MOUNTAINS AND SURROUNDING AREA, CENTRAL LABRADOR

by

A. Thomas, V. Jackson, and G. Finn*

INTRODUCTION

During the summer of 1980, geological mapping at a 1:100,000 scale was carried out in an area bordering the Red Wine Mountains, 125 km northwest of Goose Bay, covering N.T.S. sheets 13E/10, 11, 15, and 13F/12, 13. Mapping was completed by helicopter supported foot traversing and reconnaissance style helicopter traversing. Exposure over much of the area is poor, with extensive boulder fields, sand plains and areas of string bog predominating.

The area has been previously covered at a scale of 1:253,440 (1 inch to 4 miles) by Stevenson (1967, 1969) and parts of sheets 13E/11 and 13E/15 at a more detailed scale by Geiger (1961). The Ptarmigan Complex within the Red Wine Mountains has been mapped by Emslie *et al.* (1978) and their work from N.T.S. sheets 13E/9 and 13E/16 has been compiled and included within this report. A recent study of the Red Wine Alkaline Intrusive Suite has been done by Curtis and Currie (in press). Rocks of the Seal Lake Group have been mapped at reconnaissance scale by Fahrig (1959), Brummer and Mann (1961), Roscoe and Emslie (1973) and at more detailed scale by Frobisher Ltd., Brinex and Cominco.

GENERAL GEOLOGY

The area immediately surrounding the Red Wine Mountains is underlain by a basement terrain consisting of Aphebian or older Hope Lake and Disappointment Lake gneisses. The basement gneisses are intruded by, and in fault contact with, late Hudsonian or Elsonian granitic rocks of the North Pole Brook Intrusive Suite. Late Aphebian or Paleohelikian Beaver gneiss is in concordant contact with the older gneisses; however, the contact with the granitic rocks is locally faulted and obscured by tectonism. In the western portion of the map area, quartz monzonite and monzonite of probable Paleohelikian age intrude rocks of the North Pole Brook suite. Highly deformed, granulite grade charnockitic gneiss and medium to coarse grained recrystallized gabbro, also of probable Paleohelikian age, are restricted to the Red Wine Mountains (Emslie *et al.*, 1978), the western boundary of which is marked by reverse faults.

Paleohelikian intrusive rocks also include the Shabogamo gabbro, Arc Lake Intrusive Suite and the associated metamorphosed agpaitic rocks of the Red Wine Alkaline Intrusive Suite. In the northwestern part of the map area, diabase and gabbro sills, basalt flows and quartzite of the Neohelikian Seal Lake Group unconformably overlie the granitic terrain. All rocks have been deformed and metamorphosed during the Grenville Orogeny but they are polydeformed and it is probable that relict pre-Grenvillian fabrics occur at least in parts of the map area.

Hope Lake gneiss (Unit 1)

Rocks of the Hope Lake gneiss underlie much of the Red Wine Mountains and have been described by Emslie *et al.* (1978). The gneiss weathers pink or beige, is primarily leucocratic with minor mafic zones and is fine to medium grained. It is banded on a small scale and normally foliated. Felsic quartz and feldspar rich bands alternate with more mafic bands comprising hypersthene, sillimanite, biotite, hornblende and sapphirine. Magnetite, pyrite and garnet are minor constituents. Also present

* University of Western Ontario

LEGEND

NEOHELIKIAN

Seal Lake Group

14 **Bessie Lake Formation:** 14a, Amygdaloidal to massive green basalt flows interbedded with feldspathic to clean, gritty medium to coarse white quartzite.

Wuchusk Lake Formation: 14b, Gabbro sills, diabase dikes and sills,siltstone, shale, argillite and interbedded chert.

PALEOHELIKIAN

13 **Red Wine Alkaline Intrusive Suite:** 13a, Green pyroxenic-aenigmatitic gneiss; 13b, blue-black omphacitic and nephelinic gneiss; 13c, leucocratic, arfvedsonite, feldspar gneiss ± nepheline, pyroxene, eudialyte; 13d, malignite, nepheline syenite.

12 Peralkaline granite

11 **Shabogamo Gabbro:** Medium to coarse grained olivine bearing leucogabbro exhibiting fresh igneous texture.

10 **Gabbro:** Fine to medium grained massive to foliated and recrystallized pyroxene bearing gabbro, leucogabbro, norite and diabase.

9 Charnockitic gneiss

8 Coarse grained massive amphibolite

PALEOHELIKIAN - APHEBIAN

7 Quartz monzonite - monzonite

6 Tonalite gneiss

5 **North Pole Brook Intrusive Suite:** 5a, Megacrystic biotite granodiorite - quartz monzonite; 5b, equigranular biotite granodiorite - quartz monzonite; 5c, recrystallized megacrystic granodiorite - quartz monzonite; 5d, gneissic equivalents of above units; 5e, quartz diorite - diorite.

4 **Beaver Gneiss:** Banded to massive, medium grained, garnet-iferous amphibolite.

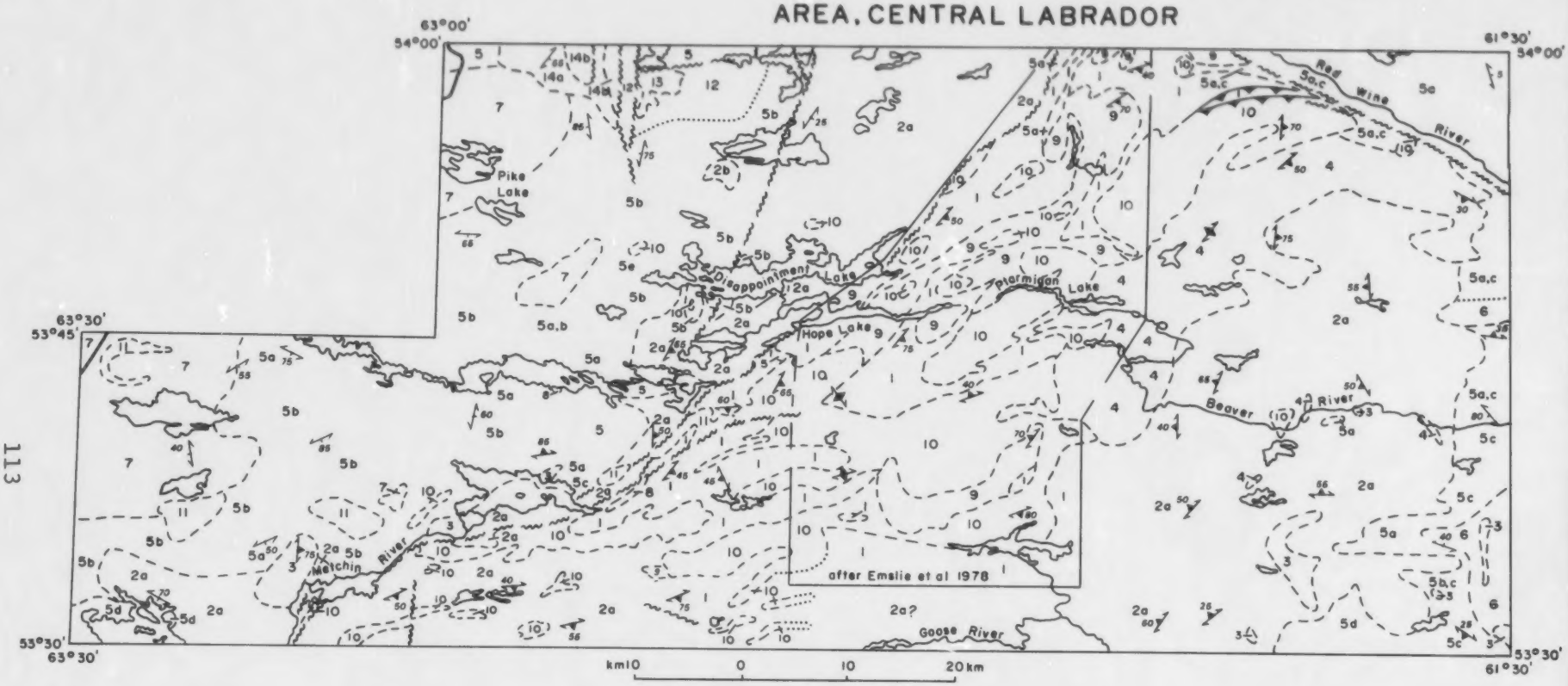
APHEBIAN - ARCHEAN

3 **Kyanite Gneiss:** Siliceous white kyanite, sillimanite, biotite, garnet, muscovite gneiss.

2 **Disappointment Lake Gneiss:** 2a, Pink sillimanite, biotite quartzofeldspathic gneiss, contains amphibolite pods and metadiabase dikes; 2b, chlorite, muscovite schist.

1 **Hope Lake Gneiss:** Pink to beige hypersthene, sillimanite, biotite, sapphirine bearing banded quartzofeldspathic gneiss, contains amphibolite pods and metadiabase dikes.

GEOLOGY OF THE RED WINE MOUNTAINS AND SURROUNDING AREA, CENTRAL LABRADOR



within the gneiss are amphibolite pods up to 2 m long by 0.25 m wide which represent metamorphosed boudins of diabase. The gneiss is considered to be a deeper crustal level equivalent of the Disappointment Lake gneiss. A Rb-Sr errorchron age of 1675 Ma* has been determined on Hope Lake gneiss and a U-Pb date of 1650 Ma has been determined on monzo-diorite closely associated with the gneiss (Emslie, personal communication, 1980). These dates indicate that the gneiss may constitute the relict deep level part of a Hudsonian mobile belt down the eastern side of the Labrador Trough. The gneiss may also be correlative with the Wilson Lake granulite, just south of the map area, which has given a preliminary K-Ar date on biotite (Gittens, personal communication, 1979) of 2200 Ma. Another possibility is that the gneiss in whole or in part represents high grade, tectonized equivalents of North Pole Brook Intrusive rocks which have been dated at 1654 Ma. The aluminous nature of the gneiss, exemplified by the common occurrence of sillimanite and sapphirine, suggests a sedimentary protolith for the unit and favors the first alternative.

Disappointment Lake gneiss (Unit 2)

Extensive exposures of Disappointment Lake gneiss (Unit 2a) occur in the eastern and northwestern parts of the map area on either side of the Red Wine Mountains. The gneiss has a granodioritic composition, is most commonly pink on fresh and weathered surfaces, fine to medium grained (0.5 to 2 mm) and uniformly banded on a small scale. Quartz and feldspar bands up to 2 cm wide alternate with anastomosing biotite, sillimanite, muscovite and magnetite bands of comparable width. Garnet and kyanite(?) are local accessory phases present in the gneiss on the eastern side of the Red Wine Mountains. Deformed leucocratic pink pegmatite zones and dikes are probably the result of *in situ* partial melting of the gneiss. Whereas dikes crosscut the banding, pegmatite sweat zones in some places crosscut and in others are parallel to banding. Highly contorted folds are often sheared parallel to and injected by pegmatitic material along their axial planes.

Within the gneiss, pods and aligned strings of pods of massive to banded amphibolite consisting of hornblende, biotite, plagioclase, magnetite and pyrite represent boudinaged metadiabase dikes. Several exposures of highly crenulated schist (Unit 2b) occur as rafts within granitoids adjacent to the gneiss terrain north of Disappointment Lake and have been included within the Disappointment Lake gneiss unit. The rock consists of chlorite, sericitic muscovite, magnetite and an unidentified, nearly isotropic, bladed mineral. It is extensively altered and deformed, exhibiting at least two periods of deformation.

The Disappointment Lake gneiss is thought to be Aphebian (see Thomas, 1980a) and to have been derived from a sedimentary protolith.

Kyanite gneiss (Unit 3)

This unit is minor in occurrence and is found in the southeast part of the area and west of the Metchin River. The rock consists of white to gray weathering, well banded, medium to coarse grained gneiss (grain size averages 0.2 to 0.5 cm). Mafic bands up to 0.5 cm in width consist of biotite and muscovite with minor euhedral garnet. These alternate with white

* All rubidium-strontium dates in this report are based on a ^{87}Rb decay constant of $\lambda = 1.42 \times 10^{-11}$ yr^{-1}.

siliceous quartz, feldspar, kyanite and or sillimanite bands up to 2 cm in width which become locally pegmatitic.

The quartz-kyanite rich nature of this rock suggests a sedimentary protolith but, at the present time, its relationship to other gneiss units within the map area is unknown.

Beaver gneiss (Unit 4)

Melanocratic, medium grained, massive to banded amphibolite comprises the Beaver gneiss, which occurs along the southeastern margin of the Red Wine Mountains massif. The banding is most commonly developed on a centimetre scale but may vary up to a metre in width. Garnet and magnetite rich quartzofeldspathic layers alternate with locally garnetiferous mafic layers containing hornblende, pyroxene, biotite, minor magnetite and pyrite. Rarely, small (1 m long) ultramafic boudins, rich in chlorite and actinolite, are developed parallel to banding. Emslie *et al.* (1978) suggest that the gneiss is Aphebian in age and represents a fairly thick metasedimentary succession. Based on this study, Beaver gneiss is presently thought to be derived from a mafic igneous protolith, possibly related to the numerous gabbro and leuconorite bodies with which it is spatially associated.

North Pole Brook Intrusive Suite (Unit 5)

Rocks of this plutonic suite are intrusive into the older Hope Lake and Disappointment Lake gneisses (as evidenced by intrusive contacts and differences in intensity and style of deformation between the two units) although intense shearing and deformation near the contacts often obscures this relationship. They are found in the western and eastern parts of the map area on either side and north of the Red Wine Mountains massif. The suite is differentiated and comprises granite, granodiorite-quartz monzonite, quartz diorite and diorite. Compositional and textural variations are subtle and contacts between the various subunits are gradational.

Pink to buff weathering biotite-hornblende granodiorite-quartz monzonite is the most typical rock type found within the suite. It is commonly megacrystic (Unit 5a) with pink or purple microcline and orthoclase phenocrysts up to 4 cm by 3 cm set in a fine to medium grained, pink to gray, quartz, plagioclase, K-feldspar, biotite and hornblende groundmass. The phenocrysts may be zoned and are usually euhedral. Equigranular granodiorite-quartz monzonite (Unit 5b) consists of quartz, plagioclase (oligoclase-andesine), K-feldspar, biotite, magnetite, subordinate hornblende and rare muscovite. The grain size of this rock varies but averages approximately 0.5 cm.

Towards the southern part of the map area, rocks of the North Pole Brook Suite become progressively recrystallized and adopt a gneissic texture. Recrystallized megacrystic granodiorite-quartz monzonite (Unit 5c) is generally massive to moderately foliated but, instead of the igneous texture normally found in the remainder of the suite, polygonal texture dominates. The original euhedral shape of the phenocrysts is preserved. Gneissic equivalents of both equigranular and megacrystic North Pole Brook rocks (Unit 5d) occur in the extreme southeast and southwest parts of the map area. There, the rocks are banded quartzofeldspathic gneisses consisting of quartz, plagioclase, K-feldspar, biotite, hornblende, magnetite and garnet. Phenocrysts, though still identifiable, are stretched into lenticular augen or feldspathic bands up to 1 cm wide. Biotite and hornblende are also segregated into distinct mafic bands from 0.5 to 1.5 cm in width. Groundmass quartz and feldspar are recrystallized and contained in bands of comparable width. Gneissic equivalents tend to be more biotite rich than either of the

equigranular or megacrystic units. Quartz diorite and diorite (Unit 5e) constitute a volumetrically minor proportion of the suite and are confined to the western part of the map area. Their mineralogy is similar to that of the other rocks of the suite but the percentages of plagioclase, biotite and hornblende are greater. These rocks are gray and equigranular with a grain size averaging 0.2 to 0.5 cm. They are massive to weakly foliated and no gneissic equivalents of them have yet been found.

Rocks of the North Pole Brook Suite have been strongly foliated and/or cataclastically deformed in the vicinity of the faults that define the northwestern and northeastern boundaries of the Red Wine Mountains massif. The North Pole Brook Intrusive Suite has been dated at 1654 ± 22 Ma and possibly represents a band of late to post-kinematic Hudsonian granitoids probably related to rocks in the Churchill Structural Province to the north. It is emphasized here, however, that most if not all of the deformation in the unit resulted from the Grenville Orogeny.

Tonalite Gneiss (Unit 6)

A few outcrops of gray, medium grained, biotite-hornblende tonalite gneiss and quartz diorite were noted near the eastern margin of the map area. These rocks, which contain plagioclase, quartz, biotite, hornblende and an abundance of pink scapolite (Ryan, this volume) are most commonly foliated or gneissic, but may be locally massive. The unit is more widespread in occurrence within the adjoining map sheet to the east (see Ryan, this volume).

Quartz Monzonite - Monzonite (Unit 7)

Pink weathering, leucocratic, medium grained quartz monzonite to monzonite intrudes rocks of the North Pole Brook Suite in the extreme western part of the map area. It is massive to weakly foliated or sheared and contains plagioclase, K-feldspar, minor quartz, biotite, chlorite, muscovite and abundant epidote. Aplitic and pegmatitic phases are present and presumably in gradational contact with the more widespread medium grained rock type.

The quartz monzonite-monzonite is thought to be Paleohelikian in age and younger than granitoids belonging to the North Pole Brook Suite. However, this unit has a close spatial relationship with rocks of the North Pole Brook Suite and is similar in composition, suggesting a possible genetic link.

Massive Amphibolite (Unit 8)

This unit is relatively rare and occurs within the western granitoid terrain and within Hope Lake gneiss along the southwestern margin of the Red Wine Mountains massif. It is present as rounded bodies in granodiorite or as distinct layers within gneiss. Outside of the mountains, the rock is medium to coarse grained (up to 1 cm) and consists of hornblende, plagioclase, magnetite and minor quartz. Within the mountains, hypersthene and garnet are additional constituents. The rock is usually massive but, within the mountains, a strong lineation is defined by the alignment of hornblende and plagioclase crystals. The amphibolite is thought to represent early Paleohelikian mafic bodies and sills which have intruded into a pre-metamorphic granitoid - sediment succession now represented by Hope Lake gneiss.

Charnockitic gneiss (Unit 9)

Restricted in occurrence to the Red Wine Mountains massif, this rock is buff to greasy brown on fresh surface and commonly weathers a rusty brown color. It is medium grained (0.3 cm) and although locally massive, is most typically foliated or gneissic. Near faults within and at the borders of the Red Wine Mountains, the gneiss becomes cataclastic. Emslie *et al.* (1978) have

determined a compositional range from monzodiorite to quartz monzonite for the gneiss, which contains quartz, K-feldspar, plagioclase, orthopyroxene, clinopyroxene, biotite, hornblende, magnetite, minor pyrite and rare garnet. K-feldspar and hypersthene porphyroblasts are common, as are granitic sweats and localized pyroxene rich segregations. This gneiss is closely associated with gabbroic rocks in the mountains and may represent cataclasized hypersthene bearing plutonic bodies. At the present time, it is not known whether these bodies are related to rocks of the North Pole Brook Intrusive Suite.

Gabbro (Unit 10)

Large bodies of gabbro, leucogabbro, norite and diabase occur within the Red Wine Mountains massif, and to a lesser extent in the surrounding terrain. These rocks are generally fine to medium grained and foliated, although the centres of some of the larger bodies may be coarse grained and display relict igneous layering as well as ophitic to subophitic textures. The borders of most of the larger bodies are severely deformed.

Plagioclase, orthopyroxene, clinopyroxene and hornblende are the main minerals. Biotite, quartz, magnetite and pyrite are subordinate in amount, although localized magnetite and pyrite concentrations occur. The gabbroids are in intrusive contact with the surrounding gneisses. Chilled margins, baking of the gneiss resulting in garnet rich zones along the contacts, inclusions of baked gneiss within gabbro, and pyritiferous zones along the contacts are observed. Diabase dikes were found at one locality crosscutting a gabbro body and may constitute a late phase of Unit 10. In addition, angular blocks of diabase with concentric chilled margins and remnant igneous layering are abundant within quartzofeldspathic gneiss near the contact between the gneisses and gabbroids. These probably represent dikes which have been broken and brecciated by subsequent deformation. The gabbroid rocks within the massif are thought to be of Paleohelikian age and closely related to the Elsonian anorthosite bodies.

Shabogamo gabbro (Unit 11)

Gabbro and leucogabbro intrude the granitoid terrain in the western part of the map area. These rocks have been tentatively correlated with the Shabogamo gabbro in western Labrador. They are medium to coarse grained, massive, olivine bearing and exhibit fresh igneous textures. Plagioclase laths up to 8 cm long are ophitically enclosed in pyroxene and altered olivine. Interstitial magnetite - ilmenite crystals as large as 2 cm are present along with spinel. Corona textures are commonly developed and are characteristic of this unit. In general, pyroxenes weather in relief and the rock where extremely weathered is rusty and friable. Leucogabbro is blue-gray on fresh surface, composed almost entirely of plagioclase with minor pyroxene. The granitoid rocks in contact with the gabbro have been baked and leached to a white color. The relationship of Shabogamo gabbro to most of the gabbroids in the Red Wine Mountains massif is uncertain. Massive, coarse grained cores of the larger Unit 10 gabbro bodies in the Red Wine Mountains may be equivalent to Shabogamo gabbro, in which case the finer grained foliated varieties in the mountains may represent deformed Shabogamo gabbro. The age of the Shabogamo Intrusive Suite in western Labrador has been determined as 1390 Ma (see Geochronology, this volume).

Peralkaline granite (Unit 12)

A small amount of peralkaline granite belonging to the Arc Lake Intrusive Suite (Thomas, 1980b) outcrops in the extreme northwest corner of the map area. It consists of quartz, plagioclase, aegirine, arfvedsonite-

riebeckite, sphene and zircon. The rock is medium grained (0.3 cm) and sheared, exhibiting a moderate to strong foliation. Peralkaline granite is closely linked spatially, chemically and time-stratigraphically with rocks of the Red Wine Alkaline Intrusive Suite and Letitia Lake Group.

Red Wine Alkaline Intrusive Suite (Unit 13)

Rocks of this unit outcrop with peralkaline granite in the northwest corner of the map area. The terminology and description of these rocks is after Curtis and Currie (in press). Green melanocratic gneiss (13a) occurs as pods and bands peripheral to agpaitic plutons. It consists of jadeitic pyroxene, arfvedsonite, nepheline, feldspar, eudialyte, biotite, apatite, pectolite and aenigmatite. Blue-black melanocratic gneiss (13b) also occurs as elongate pods associated with green gneiss and consists of omphacitic pyroxene, arfvedsonite, albite, microcline, nepheline, pectolite, aenigmatite, eudialyte and fluorite. Strongly foliated and recrystallized lenticular pods of leucocratic gneiss (13c) consist of omphacitic to aegirinic pyroxene, arfvedsonite, albite, microcline, nepheline, pectolite, aenigmatite, eudialyte and fluorite. Malignite (nepheline syenite with a color index between 50 and 90) and nepheline syenite (13d) occur as large, irregular pods of coarse grained to pegmatitic rock with igneous or relict igneous textures. These rocks contain arfvedsonite, albite, microcline, nepheline, eudialyte, aenigmatite and aegirine. The Rb-Sr age determined by Curtis and Currie (in press) for this suite of rocks is 1392 $\pm$ 75 Ma.

Seal Lake Group (Unit 14)

Seal Lake Group rocks unconformably overlie granitoids of Unit 5 along the northwestern boundary of the map area, but only the lowermost two formations are exposed. The Bessie Lake Formation (14a) consists of 1280 m (Brummer and Mann, 1961) of amygdaloidal to massive, green basalt flows interbedded with coarse to medium grained, clean to arkosic white quartzite. Quartzite is more feldspathic, gritty and conglomeratic near the base of the formation.

The Wuchusk Lake Formation (14b) conformably overlies the Bessie Lake Formation and consists of approximately 6096 m (Brummer and Mann, 1961) of gabbro sills, diabase sills and dikes, siltstone, shale, argillite and interbedded chert. The sills comprise most of this unit and form prominent ridges, whereas sedimentary rocks weather more readily and are found as minor outcrops in the valleys.

Wanless and Loveridge (1978) have determined a Rb-Sr age of 1323 $\pm$ 92 Ma for rocks of the Seal Lake Group.

STRUCTURE

At least four periods of deformation are recognized within the map area. The first period (D_1) resulted in the formation of gneissic bands within the Hope and Disappointment Lake gneisses. East of the Red Wine Mountains, the gneisses were deformed by D_2 into regional, open to closed, asymmetrical folds. These F_2 fold axes generally trend in a north-south direction but, in the east-central part of the map area, undulate between northwest and northeast. F_2 axial planes normally dip towards the west at moderate to steep angles or are vertical.

Within the Red Wine Mountains, the F_2 structures are refolded by D_3 into regional isoclinal F_3 folds, so that both F_2 and F_3 folds are overturned to the northwest, have parallel or subparallel axial planes that trend northeast and dip steeply to the southeast, and have fold axes which plunge moderately to the southwest. F_2 fold axes have been rotated into parallelism with F_3 fold axes and an intense mineral stretching lineation

(L_x), is developed parallel to these. The lineation is termed L_x since it may incorporate both L_1 and L_2 components which are now parallel. D_3 is characterized by a large amount of strain and a northerly or north-northwesterly transport direction is indicated.

The fourth period of deformation (D_4) has resulted in a gentle open warping about east-west trending axes; this forms a mushroom type interference pattern between major folds within the area. In addition, this deformation has caused L_x lineations to vary from a gentle northerly plunge, through horizontal, to a gentle southerly plunge.

Structural deformation in the area culminated in moderate to high angle reverse faulting. Granitoid terrain northwest and north of the Red Wine Mountains has acted as a buttress against which the gneisses and gabbroids have been thrust, so that major fault zones occur along the Red Wine River valley and along the western margin of the Red Wine Mountains massif. The granitoids have reacted to tectonism by shearing and recrystallizing.

Most of the deformation is of Grenvillian age; however, there is limited evidence (such as contrasting styles, intensities and orientations of deformation) that the D_1 gneissic banding and some of the granitoid fabrics in the North Pole Brook Intrusive Suite are pre-Grenvillian (presumably Hudsonian).

METAMORPHISM

Rocks within the Red Wine Mountains massif have been metamorphosed to granulite grade, as demonstrated by hypersthene + sillimanite + quartz ± garnet ± biotite and sapphirine + quartz ± garnet assemblages (Emslie *et al.*, 1978). East and west of the Red Wine Mountains, the typical mineral assemblages in quartzofeldspathic gneisses are sillimanite + quartz + plagioclase + biotite ± garnet and kyanite + quartz + plagioclase + biotite ± garnet. In mafic rocks, the assemblage is hornblende + plagioclase ± garnet ± biotite. These assemblages indicate a metamorphic grade for these rocks of at least middle to upper amphibilite.

The granitoid rocks west and north of the Red Wine Mountains do not have compositions conducive to the development of complete diagnostic metamorphic mineral assemblages but, based on the partial assemblage of secondary biotite + muscovite + epidote, their indicated grade is middle to upper greenschist. The metamorphic grade of rocks belonging to the Red Wine Alkaline Intrusive Suite has been estimated by Curtis and Currie (in press) to be middle to upper amphibolite.

The presence of primary sedimentary textures and structures as well as a quartz + albite + chlorite + epidote + muscovite mineral assemblage shows that rocks belonging to the Seal Lake Group which outcrop along the northwest margin of the map area are metamorphosed to lower greenschist grade.

Metamorphism in all rocks except the Hope Lake and Disappointment Lake gneisses is of Grenvillian age. In addition to being metamorphosed during the Grenville Orogeny, it is thought that these two units were also affected by the Hudsonian Orogeny.

MINERALIZATION

Quartzofeldspathic rocks of the Disappointment Lake (Unit 2) and Hope Lake (Unit 1) gneisses contain disseminated magnetite concentrated within thin biotite-sillimanite rich mafic layers. Amphibolitic rocks belonging to the Beaver gneiss (Unit 4) and the gabbroic rocks (Unit 10) contain local concentrations of disseminated magnetite resulting in moderate to strong aeromagnetic anomalies. These units also contain rusty zones due to minor concentrations of disseminated pyrite and pyrrhotite.

ACKNOWLEDGEMENTS

Randy Hiscock, Geralyn Lynch, Damien Morrissey and Helen Norman provided capable field assistance. We are grateful to fixed wing pilot Mike Byrne and helicopter pilots Ted Acheson, Sandy Huntley, John Innis and John MacDonald, who went above and beyond the call of duty numerous times in a summer riddled with atrocious weather and marginal flying conditions. Expediters Wayne Tuttle and "Ejay" Tuttle are thanked for providing logistical support from Goose Bay.

REFERENCES

Brummer, J.J. and Mann, E.L.
1961: Geology of the Seal Lake area, Labrador. Geological Society of America Bulletin, Volume 72, pages 1361-1382.

Curtis, L.W. and Currie, K.L.
(in press): Geology and petrology of the Red Wine alkaline complex, central Labrador. Geological Survey of Canada Bulletin.

Emslie, R.F., Hulbert, L.J., Brett, C.P. and Garson, D.F.
1978: Geology of the Red Wine Mountains, Labrador: The Ptarmigan complex. *In* Current Research, Part A, Geological Survey of Canada, Paper 78-1A, pages 129-134.

Fahrig, W.F.
1959: Snegamook Lake, Newfoundland. Geological Survey of Canada, Map 1079A.

Geiger, K.W.
1961: Reconnaissance geology and mineral deposits of the Wilson Lake - Winokapau Lake area, Labrador. Ph.D. thesis, Cornell University.

Roscoe, S.M. and Emslie, R.F.
1973: Kasheshibaw Lake (east half), Newfoundland-Quebec. Geological Survey of Canada, Map 1342A.

Stevenson, I.M.
1967: Goose Bay map area, Labrador (13F). Geological Survey of Canada, Paper 67-33.

1969: Lac Brule and Winokapau Lake map areas, Newfoundland and Quebec (13D, 13E). Geological Survey of Canada, Paper 67-69.

Thomas, A.
1980a: Geology of the southwestern margin of the Central Mineral Belt. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 166-176.

Thomas, A.
1980b: A summary of geology and data collected during 1978 in the Red Wine Lake - Letitia Lake area, central Labrador. Newfoundland Department of Mines and Energy, Mineral Development Division, Open File Report 13L (56).

Wanless, R.K. and Loveridge, W.D.
1978: Rubidium-strontium isotopic age studies, Report 2 (Canadian Shield). Geological Survey of Canada, Paper 77-14.

THE GEOLOGY OF THE RIGOLET REGION, LABRADOR

by

C.F. Gower, N. Noel, and R.T. Gillespie

INTRODUCTION

This report summarizes the initial results of reconnaissance mapping at 1:100,000 scale conducted in the Rigolet region during the 1980 field season. The work is part of a broader project to remap the Grenville Province in eastern Labrador. This project was started in the Sandwich Bay area (Cherry, 1978a, 1978b) and continued in the Benedict Mountains region (Gower, 1980).

One specific objective of the 1980 field season was to map as much of the intervening district as possible in an attempt to establish continuity between previous remapping. Another important consideration is that the region is on strike with the Double Mer area (Bailey, 1980), where uranium mineralization has been found.

PREVIOUS WORK

The region is located near the northern margin of the Grenville Province, as recently redefined by Gower *et al.* (1980). The early work in the region was done by Daly (1902), Kindle (1924), Douglas (1953), Christie *et al.* (1953), and Kranck (1939, 1953). Their investigations were mainly confined to descriptions of specific coastal localities.

The first systematic mapping was completed by Eade (1962) and Stevenson (1970). Stevenson's 1:250,000 scale map includes the northern half of the Rigolet region and shows the area as underlain by banded and migmatitic, granitic and amphibolitic gneiss. Poorly exposed areas are generally interpreted as paragneisses. The southern half of the Rigolet region is covered by the 1:500,000 scale map of Eade. The district is shown as mainly granitic gneiss but areas of paragneiss, massive to poorly foliated granitoid rock, and anorthosite/anorthositic gabbro are also delineated.

No geochronological data are available within the region. Grasty *et al.* (1969) report a whole rock K/Ar age of 1128 ± 10 Ma from a hornblende lamprophyre dike on North Stag Island immediately east of the map area (latitude 54°05', longitude 57°10'). Emslie (1976) quotes K-Ar ages of 1533 ± 45 Ma and 1400 ± 57 Ma on hornblendes from the Mealy Mountains Intrusive Suite and Gittins (1972) reports K/Ar whole rock ages of 1123 ± 50 Ma and 1078 ± 48 Ma on basaltic dikes intruding the Mealy Mountains Intrusive Suite.

DESCRIPTION OF UNITS

Paragneisses (Unit 1)

Unit 1 embraces a range of upper amphibolite facies metamorphic rocks interpreted as paragneisses. Rock types include quartzite, marble, sillimanite + garnet pelitic schists, garnet+biotite psammitic schists and some more mafic rich layers which may have been derived from a mafelsic pyroclastic protolith.

The most extensive areas of quartzite occur in the southwest part of the region and are best exposed on the shore of Lake Melville south-southeast of St. John Island. Here they are gray, white, and pink weathering, massive to thickly layered orthoquartzites with some biotite rich partings. About 15 km farther east orthoquartzite is interlayered with rusty weathering quartz + feldspar + biotite + garnet psammitic schists, possibly sillimanite bearing.

LEGEND

HADRYNIAN

14 Double Mer Formation: Red conglomerate and arkose.

HELIKIAN OR EARLIER

13 Gabbro, leucogabbro, diabase; some ultramafite and anorthosite; metamorphosed in part; includes Michael Gabbro.

12 Mealy Mountains Intrusive Suite: Anorthosite and anorthositic gabbro.

11 Medium to coarse grained, pale pink syenite to alkali feldspar quartz syenite; locally monzonite; massive to foliated.

10 Medium grained, gray, monzonite to quartz diorite; strongly foliated and/or lineated.

9 Medium grained, pink to red, syenite to monzonite, grading into hornblende granodiorite; foliated to gneissic.

8 Medium to coarse grained, pink, biotite granite to granodiorite; massive to foliated.

7 Coarse grained, pink to buff, seriate textured hornblende granodiorite; foliated.

6 Coarse grained, pink, megacrystic, biotite granodiorite; augen gneiss in part; foliated to gneissic.

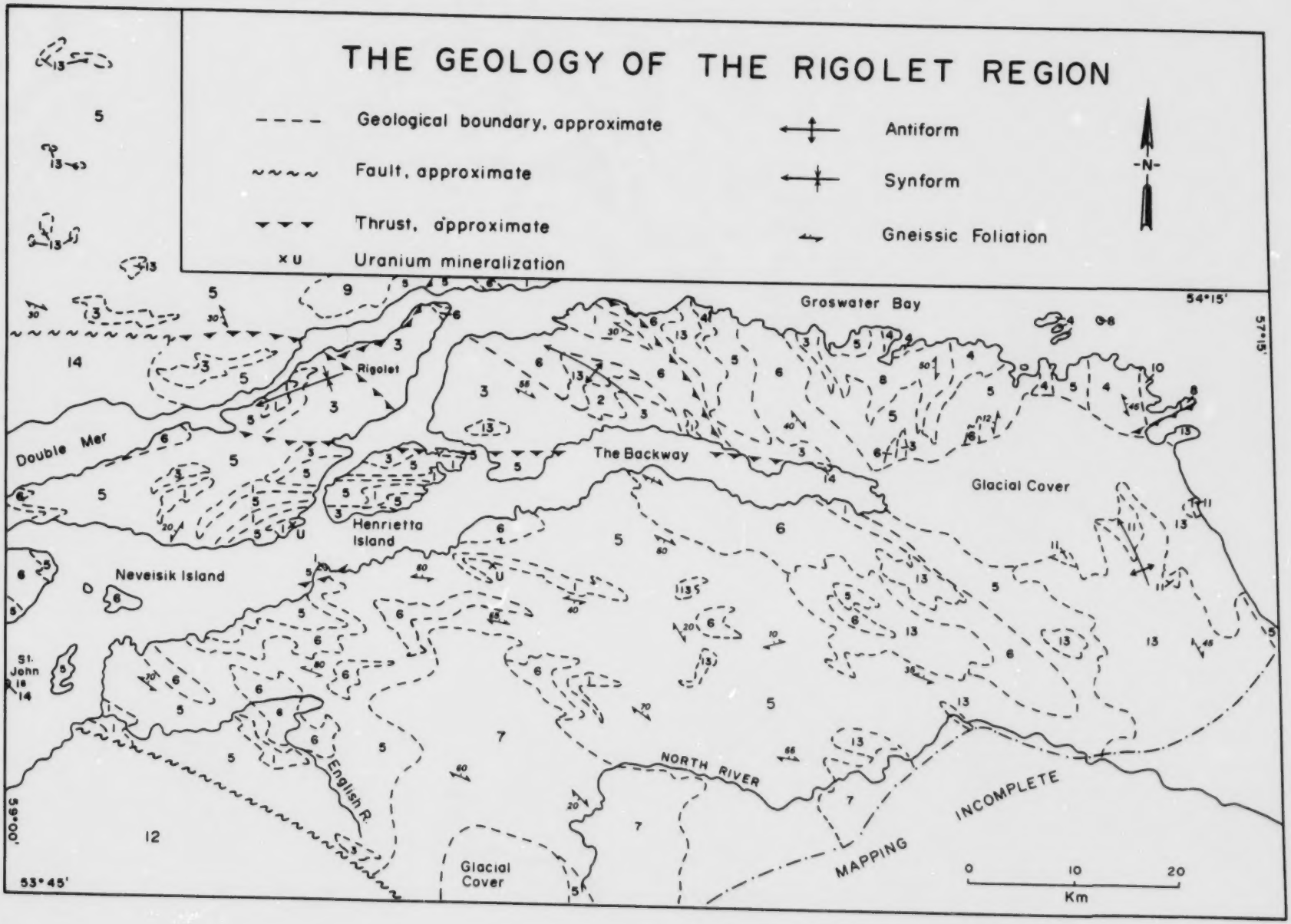
5 Medium grained, gray and pink, biotite and hornblende, granodiorite to tonalite gneiss; foliated to gneissic.

4 Medium grained, gray, biotite tonalite gneiss; discontinuously to well banded.

3 Medium grained, gray, hornblende quartz diorite to tonalite; foliated to gneissic.

2 Intercalated, medium grained, biotitic amphibolite and microgranite/aplite; discontinuous or "lensy" banded fabric (protolith possibly pyroclastic).

1 Quartzite, marble, sillimanite-garnet pelitic schists and garnet-biotite psammitic schists.


THE GEOLOGY OF THE RIGOLET REGION
Geological boundary, approximate
Fault, approximate
Thrust, approximate
Uranium mineralization
Antiform
Synform
Gneissic Foliation
-N-
Groswater Bay
54°15'
57°15'
Rigolet
Double Mer
The Backway
Glacial Cover
Henrietta Island
Neveisik Island
St. John
English R.
NORTH RIVER
INCOMPLETE MAPPING
Glacial Cover
59°00'
53°45'
0 10 20
Km

Elsewhere quartzite is a minor lithology and is associated with other metasediments. On the east end of Henrietta Island, white and rusty weathering quartzite occurs as a thinly to thickly layered rock generally less than 1 m wide. These are commonly muscovite, garnet, or sillimanite bearing. On the peninsula between Lake Melville and Double Mer, minor thinly and thickly layered quartzite is interlayered with biotite-rich schist.

Metacarbonate horizons associated with the metasediments range from almost pure marble to pale or dark green calc-silicate rocks containing abundant diopside and grossularite, and locally forsterite, spinel, and phlogopite. A spectacular white marble is exposed on the south side of Groswater Bay 15 km east-northeast of Rigolet. It has been intruded by pegmatite and a mafic dike, with both minor intrusions subsequently disharmonically deformed. Pink marble occurs as 20-30 cm wide layers associated with psammitic and pelitic schists west of Henrietta Island. Farther east, along strike, the rock contains abundant diopside with sphene, apatite, phlogopite, and forsterite. The calc-silicate layers occur as boudins enveloped in a quartzofeldspathic leucosome, probably derived from partial melting of the surrounding sillimanite + garnet pelitic schists.

A complete gradation exists between the biotite-rich pelites and the granoblastic quartz + feldspar psammites but both rocks are characterized by a mauve-colored (? spessartine) garnet. There is little doubt that the pelitic schists were derived from sediments, but it is by their common association with marble or quartzite that the psammites are also interpreted as metasediments.

Flaggy quartzofeldspathic schists, with parallel partings defined by hornblende rich layers, occur on the north side of Groswater Bay, 10 km northeast of Rigolet. These rocks contain 20-30% garnet and are locally scapolite bearing. Some rocks have a mesoscopic lensoid fabric suggestive of a pyroclastic origin; elsewhere, they are plagioclase rich and resemble layered anorthositic gabbro. These rocks are shown on the map as part of Unit 1 but a more complete subdivision of units can be anticipated pending more detailed study.

White weathering, inhomogeneous and homogeneous diatexites are closely associated with the pelitic schists. The best outcrops occur west of Henrietta Island on the north shore of Lake Melville. The rocks have a variable pegmatoid appearance related partly to extreme grain size variation, mineralogical inhomogeneity, and irregular rafts of restite materials. The diatexites extend for tens of metres across strike and hundreds of metres along strike.

Banded mafic gneiss (Unit 2)

The principle lithology is a hornblende + plagioclase + biotite + garnet rock which is generally medium grained, dark weathering, and has a well banded appearence due to alternation with a quartzofeldspathic leucosome. Commonly, the rock has a 'clotty' appearance and exhibits lensoid garnet rich enclaves. Three possible protoliths are being evaluated, namely, (i) a mafic to mafelsic pyroclast, (ii) a mafic rich graywacke, and (iii) an injected and metasomatized mafic intrusion.

Quartz diorite (Unit 3)

The most extensive development of quartz diorite is in the Rigolet area where it has been deformed into a west plunging synform. It also occurs along the north shore of The Backway, on the south side of Henrietta Island, and is interpreted to underlie the unexposed area immediately east of Rigolet.

The gneissic fabric varies from foliated to well banded and, characteristically, the rock contains irregular discontinuous, pink weathering, leucosome patches that appear to be the product of *in situ* partial melting. In places, these patches are flattened and accentuate layering. Zones containing abundant amphibolite are also present and some layers are recognizable as relict mafic dikes. Elsewhere, they have suffered injection and deformation resulting in amphibolitic gneiss.

Other textural variants include rare, sparsely megacrystic (K-feldspar), quartz diorite and hornblende-bearing granodioritic gneiss, similar to Unit 5 in part.

Tonalitic and granodioritic gneiss (Units 4 and 5)

Biotite tonalitic gneiss (Unit 4) has been distinguished provisionally from granodioritic gneiss (Unit 5) but it is probable that considerable overlap exists between these two units. Refinement of their distribution pattern can be expected after examination of stained slabs and thin sections. Both units encompass a wide range of foliated and gneissic rocks with migmatitic fabric embracing the complete spectrum from agmatite to nebulite. Banding is enhanced by amphibolite enclaves and 5-30% leucosome. Biotite, hornblende and garnet are ubiquitous mafic phases and magnetite is the most common opaque mineral. As a broad generalization, Unit 5 can be considered as equivalent to Unit 4f of Gower (1980).

These gneisses are unequivocally the product of both pre-Grenvillian and Grenvillian deformation. This is demonstrated by the presence of mafic dikes that discordantly intrude gneisses but are themselves metamorphosed to amphibolite facies rocks and reworked to become part of a later (Grenvillian) gneissosity.

Megacrystic granodiorite (Unit 6)

The megacrysts (1-5 cm) in this unit occur as unrecrystallized single crystals or polygonal aggregates. Deformation has converted both megacryst types to augen and, in extreme cases, has produced augen gneiss. Locally, e.g. 10 km east of Rigolet, two generations of K-feldspar megacrysts are present. Biotite is the principle mafic phase of this unit.

There are some areas, *e.g.* Neveisik Island, where the megacrystic granodiorite is a homogeneous, extensive unit quite distinct from the granodiorite gneiss of Unit 5. However, the two units commonly have gradational boundaries and may occur as interlayered lithologies within a single outcrop. The megacrystic granodiorite may be partly a younger unit emplaced into an older gneiss terrane and partly equivalent in age to the gneisses.

Hornblende granodiorite (Unit 7)

A large portion of the central part of the southern half of the map area is underlain by a coarse grained, homogeneous granodiorite. The unit was identified originally by Eade (1962) but its extent depicted here is greatly expanded from that previously shown.

The unit is characteristically a pinkish buff/orange weathering rock. Hornblende is the dominant mafic phase, though biotite and, more rarely, garnet are also found. The unit is homogeneous and moderately to strongly foliated. It seems to lack the deformed mafic dikes that characterize previously described units and, hence, is possibly younger.

Biotite granite (Unit 8)

Pink weathering granite is exposed on the south side of Groswater Bay, 40 km east of Rigolet. A similar lithology is present farther east along the coast and on offshore islands, and is grouped as part of the same unit.

The granite is medium to coarse grained, leucocratic and homogeneous. Biotite and magnetite are the principle mafic phases. The fabric varies from massive to strongly foliated and/or lineated. In places, the rock contains diffuse, streaked out, K-feldspar-enriched segregations. The rock has been intruded by up to three generations of mafic dikes, all of which have been affected by amphibolite facies metamorphism.

Syenite to monzonite (Unit 9)

Unit 9 occurs in only one area northwest of Rigolet. It is generally pink weathering and medium grained and contains recrystallized plagioclase crystals up to 1 cm in diameter. These are set in a matrix composed of K-feldspar, hornblende, biotite, and quartz. The fabric varies from massive or weakly foliated to nebulitic or schlieritic.

Monzonite to quartz diorite (Unit 10)

Typically, this unit is a honey weathering, coarse grained rock with a strong lineation. Its mineralogy is primarily hornblende, plagioclase and K-feldspar with lesser amounts of biotite, quartz and garnet. Apart from rare mafic enclaves, the rock has a uniform appearance.

Syenite to alkali feldspar syenite (Unit 11)

Unit 11 occurs exclusively in the eastern part of the map area and, from limited data, seems to have a spatial association with the gabbroid rocks of Unit 13. Hornblende is the dominant mafic phase. In places, a finer grained, slightly more mafic syenite is present. The unit is locally interlayered with a coarse grained, pink weathering granite.

Mealy Mountains Intrusive Suite (Unit 12)

The Mealy Mountains Intrusive Suite has been mapped recently by Emslie (1976) and was only briefly examined during the present project. Emslie's sketch map shows most of the Mealy Mountains Intrusive Suite in the map area as comprising anorthosite and leucogabbro, but he also shows a northeast fringe of pyroxene quartz monzonite. He notes that, elsewhere, dikes of pyroxene quartz monzonite intrude anorthosite.

The shoreline in the map region was examined during the present project and found to consist of pyroxene and hornblende bearing anorthosite containing enclaves of amphibolite and quartzofeldspathic gneiss. East-northeast trending olivine diabase dikes, previously described by Emslie (1976) and dated by Gittins (1972), are also present.

Gabbroid rocks (Unit 13)

A range of gabbroid lithologies and of varied probable age are included within Unit 13. Only the large areas are shown on the accompanying sketch map but mafic sheets and irregular bodies are ubiquitous.

The gabbros in the southeast part of the region were assigned by Eade (1962) to the Anorthosite Suite but Stevenson (1970) grouped these gabbros, and all others in the region as part of the Michael Gabbro (Fahrig and Larochelle, 1972). The southeastern gabbros are thick sheets folded about north trending axes. They are massive, homogeneous, medium or coarse grained, and tend to anorthositic composition. They may be genetically distinct from the smaller gabbroid masses characteristic of the north side of Groswater Bay.

This is clear evidence of at least two phases of pre-Grenvillian mafic dike activity. The older dikes have been deformed into tight to open folds and are discordantly intruded by younger dikes.

East-northeast trending mafic dikes intrude gneisses formed during the Grenvillian Orogeny, implying a later period of diking. These have the same

trend as a suite of dikes that intrudes the Mealy Mountains.

In the eastern part of the area, there are pronounced north-northeast trending aeromagnetic anomalies which, east of Cartwright (outside the map area), are clearly related to mafic dikes. Farther south (*e.g.* Belle Isle), these dikes have been demonstrated as related to early Paleozoic volcanism (Strong and Williams, 1972).

Double Mer Formation (Unit 14)

The Double Mer Formation is a sequence of post-Grenvillian red arkoses and conglomerate described by Kindle (1924) and Stevenson (1970). A previously unrecognized outlier of Double Mer conglomerate was mapped near the east end of The Backway. The conglomerate is polymictic with clasts of gabbro (the dominant lithology), anorthosite, augen granodiorite, amphibolite, and quartzite.

Several neptunian dikes containing Double Mer material were identified on Neveisik Island and along the shoreline immediately to the south. Emslie (1976) reports neptunian dikes at lake level within the Mealy Mountains Anorthosite Suite, and points out that this implies that the Mealy Mountains (and presumably the surrounding gneisses) were uplifted prior to the deposition of the Double Mer Formation.

STRUCTURE AND METAMORPHISM

The fold pattern is extremely complex and no overall synthesis has been attempted so far. From detailed structural relationships, it is clear that final stages of deformation developed a dome and basin structural pattern. This is Grenvillian in age and is superimposed on older gneisses containing many examples of refolded folds.

Thrust faults in the area are defined by zones of brecciation or mylonitization and abundant secondary epidote and hematite. Aeromagnetic lows assist in tracing the position of some thrusts. The east trending thrust extending from Double Mer to The Backway is probably the best defined. Recumbent, north-verging folds are associated with the thrust and are well exposed at the east end of Henrietta Island and the shoreline immediately east. Aeromagnetic data and contrasting geological style suggest that there may be an additional thrust, or strike-slip fault, extending southeast from the east end of The Backway.

A fault is inferred to bound the northeast side of the Mealy Mountains Intrusive Suite on the basis of contrasting aeromagnetic trends on either side of a strong topographic lineament.

Metamorphic grade is at upper amphibolite facies but retrograde greenschist effects have developed along zones of thrusting. Some of the more diagnostic mineral assemblages include: calcite + grossularite $\pm$ diopside $\pm$ forsterite $\pm$ spinel $\pm$ phlogopite; quartz + plagioclase + biotite $\pm$ garnet $\pm$ sillimanite; quartz $\pm$ biotite $\pm$ garnet $\pm$ muscovite; and hornblende + plagioclase $\pm$ garnet $\pm$ quartz $\pm$ biotite. There is evidence of incongruent partial melting with the formation of hornblende or garnet porphyroblasts. As in many metamorphic terranes, partial melting seems to have acted as a buffer against granulite facies metamorphism.

MINERALIZATION

The paragneisses offer the greatest economic mineral potential in the region, especially for uranium mineralization. Diatexites associated with paragneiss commonly gave total count readings over 10,000 counts per second (cps). At two localities, readings of 21,000 cps and 34,000 cps were recorded. In the latter case, the diatexite was stained yellow by what are believed to be secondary uranium minerals.

In addition, the paragneisses are extremely pyritic and show minor malachite staining. In three localities, specks of molybdenite were noted; namely, in diatexite, a calc-silicate layer, and a quartz vein. A 3 m thick pyritic layer was found associated with amphibolite and microtonalite (probably a metagraywacke) on the south side of Groswater Bay 15 km east of Rigolet.

Mineral occurrences in other lithologies are rare. Chalcopyrite was found in pegmatite within a gabbro near the east end of Groswater Bay and is associated with calcite, tourmaline, quartz, and magnetite-ilmenite. Similar mineralization, malachite staining of quartz-calcite veins within gabbro, was found at the east end of The Backway.

ACKNOWLEDGEMENTS

Excellent field assistance was given by L. Green, A. Hopkins, M. Roberts, and M. Tubrett. Pilot services were provided by M. Burns of Labrador Airways and D. Abrahams and J. Danby of Universal Helicopters. Logistical support from Goose Bay was provided by E.W. Tuttle and E.J. Tuttle of the Department of Mines and Energy.

REFERENCES

Bailey, D.G.
1980: Geology of the Double Mer - Lake Melville area, Labrador. *In* Report of Activities. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Report 80-1, pages 154-160.

Cherry, M.
1978a: Geological mapping in the Sandwich Bay area, southeastern Labrador. *In* Report of Activities. *Edited by* R.V. Gibbons. Newfoundland Department of Mines and Energy, Report 78-1, pages 16-21.

1978b: Sandwich Bay, Labrador. Newfoundland Department of Mines and Energy, Mineral Development Division, Map 78176, Scale 1:100,000.

Daly, R.A.
1902: The geology of the northeast coast of Labrador. Bulletin of the Museum of Comparative Zoology, Harvard, Volume 38. Geological Series, Volume 5, Number 5, pages 205-269.

Douglas, G.V.
1953: Notes on localities visited on the Labrador coast in 1946 and 1947. Geological Survey of Canada, Paper 53-1, 67 pages.

Eade, K.E.
1962: Geology, Battle Harbour - Cartwright. Geological Survey of Canada, Map 22-1962.

Emslie, R.F.
1976: Mealy Mountains Complex, Grenville Province, southern Labrador. *In* Report of Activities, Part A. Geological Survey of Canada, Paper 76-1A, pages 165-170.

Gittins, J.
1972: A note on the age of basaltic dikes in the Mealy Mountains, Labrador, Canada. Canadian Journal of Earth Sciences, Volume 9, pages 1337-1338.

Fahrig, W.F. and Larochelle, A.
1972: Paleomagnetism of the Michael Gabbro and possible evidence of the rotation of the Makkovik Subprovince. Canadian Journal of Earth Sciences, Volume 9, pages 1287-1296.

Gower, C.F.
1980: Geology of the Benedict Mountains and surrounding areas (13J (east) and 13I). *In* Report of Activities. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Report 80-1, pages 182-191.

Gower, C.F., Ryan, A.B., Bailey, D.G. and Thomas, A.
1980: The position of the Grenville Front in eastern and central Labrador. Canadian Journal of Earth Sciences, Volume 17, pages 784-788.

Grasty, R.L., Rucklidge, J.C. and Elders, W.A.
1969: New K-Ar age determinations on rocks from the east coast of Labrador. Canadian Journal of Earth Sciences, Volume 6, pages 340-344.

Kindle, E.M.
1924: Geography and geology of Lake Melville district, Labrador Peninsula. Geological Survey of Canada, Memoir 141, 105 pages.

Kranck, E.H.
1939: Bedrock geology of the seaboard region of Newfoundland-Labrador. Newfoundland Geological Survey, Bulletin 19, 44 pages.

1953: Bedrock geology of the seaboard of Labrador between Domino Run and Hopedale, Newfoundland. Geological Survey of Canada, Bulletin 26, 41 pages.

Stevenson, I.M.
1970: Rigolet and Groswater Bay map area, Newfoundland (Labrador). Geological Survey of Canada, Paper 69-48, 24 pages.

Strong, D.F. and Williams, H.
1972: Early Paleozoic flood basalts of northwestern Newfoundland: their petrology and tectonic significance. Geological Association of Canada, Proceedings, Volume 24, pages 43-54.

THE GEOLOGY OF THE CHURCHILL FALLS AREA, LABRADOR

by

R.J. Wardle and J.M. Britton*

INTRODUCTION

The area mapped during the 1980 season comprised N.T.S. sheets 23H/10, 23H/9 and 13E/12W, and is an easterly extension of previous Mineral Development Division mapping in southwestern Labrador (Wardle, 1979; Noel and Rivers, 1979).

The area is located at the southeastern end of the Smallwood Reservoir and includes the hydroelectric townsite of Churchill Falls. Access to the townsite may be made by scheduled air service from Montreal or St. John's; by all weather road linking with the QNS & L Railway at Esker; or by tote road from Goose Bay.

Service roads connect Churchill Falls to dam sites at Orma Lake, 100 km north of the map area, to the south shore of the Forebay Reservoir, and also to the hydroelectric site of Twin Falls.

The map area is an undulatory plateau which has been deeply dissected by the east flowing Valley, Unknown, and Churchill Rivers. All of these rivers flow through deep rocky gorges and over several major waterfalls, the largest of which was Churchill Falls, which has now been divided to form the Churchill Falls hydroelectric development. Creation of the Forebay Reservoir as part of this scheme has resulted in extensive flooding of the plateau land. The accompanying map has been adjusted to show approximately the flooded areas.

Exposure on the plateau is generally very poor, with the exception of the southeast part of the area, which has a more rugged topography. Elsewhere in the area, good exposure is usually confined to the river valleys, some hill tops, and the numerous quarries and roadside outcrops created around the Forebay Reservoir.

The only previous geological mapping in the area was the reconnaissance work by Eade (1952) and Stevenson (1969) of the Geological Survey of Canada (G.S.C.). Eade shows the northwestern part of the area as underlain by banded granitic gneisses and gneissic granites and Stevenson mapped the southeastern part as paragneisses and gabbroic rocks. Some more detailed work was carried out by the British Newfoundland Exploration Company (BRINEX) during construction of the Churchill Falls site. (White, 1968; Barton and Barton, 1970; Callahan, 1968, 1969, 1973, 1980).

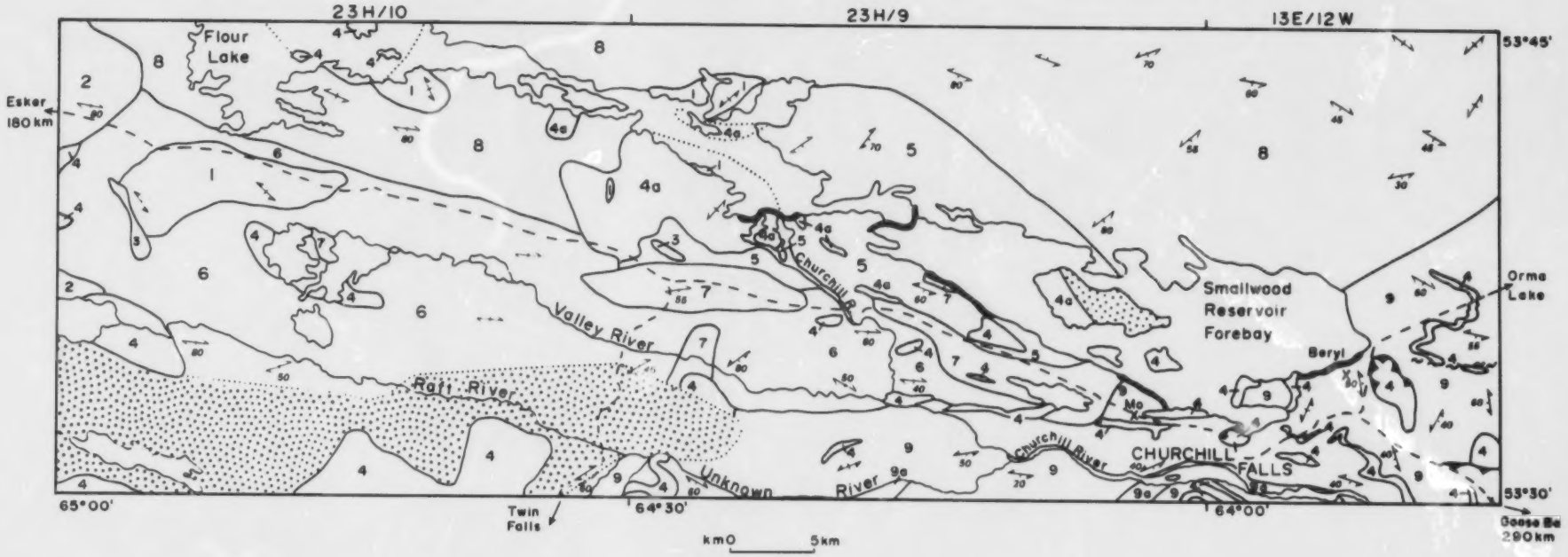
In the regional synthesis by Greene (1974), the gneisses in the northwest part of the area were assigned to the Churchill Province and those in the southeast to the Grenville Province. The Grenville Front was, therefore, inferred to extend diagonally across the area from southwest to northeast.

GENERAL GEOLOGY

The oldest rocks are various granitoid and metasedimentary gneisses of Unit 1 which are present as large inclusions within younger granitoid plutons. These are the only Hudsonian tectonites in an area previously considered to be dominantly underlain by such rocks (Greene, 1974).

Paleohelikian supracrustal sequences in the area are represented by the felsic volcanics and volcaniclastics of the Blueberry Lake Group (Unit 2). It is clear that most of the area is underlain

*Dept. of Geology, University of Toronto, Toronto, Ontario.



Road

Earth Dam

Cleavage schistosity

Gneissosity

Fault

Thrust

LEGEND

HELIKIAN

9 — *Granitoid gneisses equivalent to units 6, 7 and 8;* **9a**, *quartz-feldspar sillimanite gneiss, quartz - feldspar garnet gneiss.*

8 — *Coarse grained pink quartz monzonite; microgranite and aplite; minor diorite*

7 — *Pink microgranite and equigranular granite*

6 — *Gray quartz monzonite*

5 — *Gray monzonite*

4 — **SHABOGAMO INTRUSIVE SUITE:** *Gabbro, amphibolite;* **4a**, *biotite-hornblende gabbro*

3 — *Mafic porphyry*

2 — **BLUEBERRY LAKE GROUP:** *Felsic and mafic volcanics, volcaniclastics*

ARCHEAN OR APHEBIAN

1 — *Tonalitic gneisses, minor amphibolite;* **1a**, *biotite-sillimanite pelitic gneiss*

by graintoid and gabbroid rocks of Paleohelikian age. These are represented by the gabbroid intrusives of Unit 3 and the Shabogamo Intrusive Suite (Unit 4), which in turn have been intruded by a range of granitoid plutons represented by Units 5-8.

The entire area was deformed during the Grenvillian Orogeny and, thus, by definition lies entirely within the Grenville Province. Deformation and metamorphism associated with this event increase in intensity from northwest to southeast. As a result, the granitoid plutons of Units 5-8 become progressively metamorphosed to granitoid gneisses in the southeastern part of the area (Unit 9).

Tonalite gneisses, minor amphibolite, and sillimanite-biotite-garnet gneiss (Unit 1)

This is a very poorly exposed unit, the extent of which is defined largely on the basis of aeromagnetic lows (G.S.C. aeromagnetic maps, 1972).

Most outcrops consist of white weathering, migmatitic, tonalitic gneisses with common bands of amphibolite. These were partially mylonitized and retrogressed prior to intrusion by Helikian plutons.

Also included in the unit is a small area of quartz + biotite + sillimanite + garnet + microcline pelitic gneiss (1a) which was subsequently intensely folded and partially migmatized.

Both types of gneiss have been intruded posttectonically by the younger granitoid plutons. The tonalite-amphibolite gneisses are similar to gneisses of probable Archean age in the Gabbro Lake area (Wardle, 1979), which adjoins the western boundary of the map area.

Blueberry Lake Group (Unit 2)

This is also a very poorly exposed unit; it is delineated on the basis of only four outcrops. These consist of rhyolite and plagioclase phyric, intermediate to mafic volcanics which could be of either intrusive or extrusive origin.

The unit represents the easterly termination of the Blueberry Lake Group, the type area for which is informally defined in the Gabbro Lake area (Wardle, 1979; Noel and Rivers, 1979) The group typically consists of felsic to intermediate pyroclastics, volcaniclastics and minor hypabyssal intrusives. The latter have been dated at 1540 $\pm$ 40 Ma (Brooks *et al.*, in press).

Mafic Porphyry (Unit 3)

Mafic porphyry is only exposed at two localities in the map area; however, abundant boulders in the glacial overburden indicate that it may be more widespread.

This rock type contains large (up to 3 cm diameter) euhedral plagioclase phenocrysts in a dark, purple-gray groundmass of intermediate appearance and locally displaying a weak flow alignment. Low grade metamorphism has saussuritized the phenocrysts, producing a green coloration, and has recrystallized the groundmass to a fine granular intergrowth of epidote, albite, opaque minerals, and actinolite.

The unit is intruded by granodiorite dikes of the Unit 6 pluton. It is uncertain, however, whether Unit 3 forms a hypabyssal component of the Blueberry Lake Group or the Shabogamo Intrusive Suite, or belongs to a separate intrusive episode.

Shabogamo Intrusive Suite (Unit 4)

Gabbroid bodies of varying size and metamorphic grade occur throughout the map area. The most typical lithology is a medium to coarse grained olivine gabbro which contains irregular zones of coarse pyroxene-plagioclase pegmatite. This is identical to the large mass of Shabogamo gabbro occurring in the Gabbro Lake area to the west (Wardle, 1979)

which has been dated at 1400 Ma (Brooks *et al.*, in press).

A distinctive variety, prevalent along the southern side of the Forebay Reservoir is a melanocratic, two pyroxene-biotite gabbro (4a) in which biotite forms large 1-2 cm diameter poikilocrysts. Locally, hornblende is suspected to be an additional primary constituent and, in these instances, it is possible that the rock type has a dioritic composition.

In the southeastern part of the area, within Unit 9, the large gabbro bodies typically have coarse grained centres with clinopyroxene-garnet-spinel coronas developed around olivine and orthopyroxene. Smaller bodies of gabbro, and the margins of the larger bodies, have been converted to amphibolite schist and gneiss.

In most cases, where contact zones are exposed and well preserved (*i.e.* largely in the northeastern part of the area), the gabbro is practically always intruded by dikes of granite and pegmatite from the surrounding plutons. In the contact zones, the gabbro is also usually net veined and stoped by these younger granitoid plutons and, in many cases, there is a complete gradation over several tens of metres from granitoid crowded with xenoliths to gabbro net-veined by granitoid and pegmatite.

In many locations, however, the gabbro bodies become finer grained towards the contact zones and include zones of plagioclase phyric diabase and fine gabbro. The xenolith content of the granitoid plutons is also composed largely of diabase derived from these peripheral zones.

These relationshps could be interpreted to indicate that the gabbro is the younger unit and has produced rheomorphic remobilization ("back veining") by melting of the granitoid rocks. However, the net veined and stoped zones are extensively developed and bear no relationship to the size of the gabbro body. In fact, some of the smaller gabbroic bodies have been totally brecciated by net veining, a feature which would not be expected to result from rheomorphism. Furthermore, the granitoid plutons contain xenoliths of diabase in areas well away from exposed gabbro plutons, a feature that is also inconsistent with a rheomorphic model.

The preferred interpretation, therefore, is that in most cases the gabbros predate the granitoid intrusions. The possibility of some pre-gabbro granitoids cannot be discounted, however.

The gabbros have locally been intruded by several late, pretectonic mafic dikes which also intrude the monzonite of Unit 5.

Gray Monzonite (Unit 5)

This is a distinctive gray plutonic rock exposed in shoreline and quarry outcrops around the Forebay Reservoir. On the basis of field identification, the pluton is of monzonite composition but varies locally to monzodiorite, quartz monzonite and quartz diorite. The unit is typically gray on weathered and fresh surfaces but may be pink where it has been strongly deformed or affected by low grade alteration.

Vague compositional layering has also been observed locally within the unit.

The monzonite is generally medium to coarse grained and usually subequigranular in texture. Locally, however, microcline may form dark purple-gray phenocrysts up to 1 cm long. Otherwise, gray alkali feldspar occurs intergrown with gray plagioclase in granular texture and contains minor interstitial quartz, commonly with a blue tinge. Biotite and pyroxene (hypersthene?) are the main mafic mineral phases. Pyroxene has been partially replaced by biotite.

Gray Quartz Monzonite (Unit 6)

This is an extensive unit throughout the central part of the map area. It is usually a medium grained, white weathering quartz monzonite, gray on fresh surface, with a seriate texture in which dark purplish gray microcline forms phenocrysts up to 1 cm diameter. Granodiorite, microgranite, and microgranodiorite phases are also present locally, the latter being particularly prevalent near the Blueberry Lake Group. Biotite is the predominant mafic mineral, locally intergrown with hornblende or sphene, and commonly appears to be pseudomorphic, possibly after pyroxene.

Gray quartz monzonite intrudes Units 1, 2, 3 and 4; however, relationships to the Unit 5 monzonite are uncertain. In the only place at which the two plutons have been observed in contact, along the upper part of the Churchill River, both units have been strongly mylonitized and age relationships remain unknown.

Pink microgranite and equigranular granite (Unit 7)

This is a composite unit comprising various bodies of pink, medium grained, equigranular granite, quartz syenite, microgranite, and aplite.

Several bodies of this unit have been delineated on the accompanying map. Given the poor degree of exposure of this unit, however, it is not certain whether these represent single homogeneous plutons or zones of numerous minor intrusions.

Numerous small dikes and sheets of microgranite and aplite intrude all the other plutonic units of the area but are generally too small to be portrayed on the map. In general, these are correlated with Unit 7. It is possible, however, that in some locations they may represent late differentiates of Units 5 and 6.

A deformed variant of Unit 7 is a strongly foliated, fine grained, biotite granite exposed along the Valley River (7a).

Coarse grained porphyrytic quartz monzonite (Unit 8)

This unit extends across the northern part of the map area and is contiguous with the granitic pluton of the Lake Michikamau area (Unit 3; Nunn, this volume). Exposure of the unit is generally very poor and the position of the southern boundary is based largely on aeromagnetic interpretations.

The unit is characteristically a coarse grained, pink, quartz monzonite with seriate texture. The megacrysts are mainly microcline and vary in length up to 1.5 cm. The matrix consists of white plagioclase, locally tinged green by saussuritization, intergrown with pink alkali feldspar and interstitial quartz, the latter often having a blue tinge. Biotite is the only mafic phase.

The unit also contains abundant microgranite and aplite, both as irregular masses and dikes, as well as several thin sheetlike bodies of diabase and diorite which are believed to be late dikes (8a).

Contact relationships with other units in the area have not been observed. On the basis of lithologic similarity, the unit could be correlated with the Unit 7 granites to the south. However, if the diorite dikes are part of the Shabogamo Suite, the unit must belong to a much earlier period of intrusion.

Granitoid gneisses (Unit 9)

South of Valley River, the plutonic rocks of Units 5, 6, 7 and 8 have been progessively metamorphosed to form the migmatitic granitoid gneisses of Unit 9. The contact of Unit 9 has been drawn at the first appearance of well developed

migmatite fabrics and gneissic foliation in these rocks. In reality, this is a broad transitional zone in which areas of strongly foliated granitoid rocks interdigitate with migmatite and granitoid gneiss.

South of Churchill River, the predominant lithology within Unit 9 is a light gray to pink gneiss of quartz monzonite to granodiorite composition which is in a large part equivalent to Unit 6. Southeast and east of Forebay Reservoir, the gneisses are generally darker colored and appear to vary in composition from quartz diorite to monzonite and monzodiorite. There is little doubt that, in part, these are metamorphosed equivalents of Unit 5. Several zones within the gneisses, however, have been intruded by pretectonic dikes of amphibolitized diabase. If these dikes are related to the Shabogamo gabbros, formation of part of the gneiss protolith must have predated the intrusion of Unit 5.

To date, the various areas of gneisses have not been subdivided. In future petrographic studies, however, it should be possible to more closely define the extension of plutonic contacts into the gneiss terrains.

Scattered throughout the gneisses are abundant sheets and pods of pink granite gneiss and schistose aplite which are interpreted as metamorphosed equivalents of Units 7 and 8.

A feature of Unit 9 is the marked heterogeneity of development of migmatitic and gneissic fabrics. Throughout the gneiss terrain, numerous areas contain well preserved igneous features, *e.g.* mafic xenoliths and microcline phenocrysts, in a moderately foliated or lineated rock. These invariably grade laterally into areas of incipient migmatization in which mobilizate forms small elliptical pods or an intersecting vein system. In both cases, the leucosome veins are characteristically spotted with small biotite and/or hornblende porphyroblasts, possibly the product of incongruent melting.

These incipient migmatites often grade sharply, sometimes over distances of as little as 2 m, into zones of well banded, leucosome-rich migmatite. These zones are commonly associated with pre- or synkinematic pegmatite and aplite veins and may owe their development to the local introduction of fluids during metamorphism.

Also included within Unit 9 are several poorly defined screens of quartz + feldspar + biotite + sillimanite gneiss which may represent relict metasedimentary inclusions within the gneiss protolith (9a). The only one sufficiently large to be portrayed at map scale is located 1 km south of Churchill Falls (9a). Several areas of fine grained quartz + feldspar + biotite + garnet gneiss presently included within Unit 9 may also be of metasedimentary origin. These are largely confined to the area south of the Churchill and Unknown Rivers.

Late Dikes

Several thin dikes of olivine basalt and diabase were noted along the Valley and Upper Churchill River valleys. These dikes have approximate east-west trends and are completely post tectonic. Their age, other than being post-Helikian, is unknown.

STRUCTURE AND METAMORPHISM

All units, with the exception of the late dikes, have been varyingly affected by Grenvillian deformation. Reconnaissance studies indicate that the northwestern limit of this deformation, which was previously thought to transect the map area, lies approximately 40 km northwest of the center of the map area.

The only pre-Grenvillian structures recognized from the area are found within the gneisses of Unit 1. The

larger bodies of this unit preserve gneissic and cataclastic fabrics of northwesterly trends which were probably inherited from the Hudsonian, and possibly even Kenoran, Orogenies.

The granitoid Units 5, 6, 7, and 8 have been affected by strong, zonally developed, Grenvillian deformation and metamorphism which increases in intensity from northwest to southeast.

In the northwest, the rocks vary from undeformed to moderately foliated with biotite or chlorite S_1 fabrics. Deformation is usually associated with shearing, and zones of protomylonite and mylonite schist are common. S_1 fabric trends have an overall east-west to northeast-southwest trend with steep southerly dips, and have been deformed into broad folds by later deformation.

To the southeast, in the general area of the Forebay Reservoir, the metamorphic grade rises to upper greenschist and amphibolite facies and the granitoids become more homogeneously foliated. Mylonite zones are still present but are seen as flaggy quartz + feldspar + biotite $\pm$ muscovite augen schists in which microcline usually forms augened porphyroclasts.

Within the area of Unit 9, the gneissic textures presumably indicate the development of upper amphibolite facies conditions. Zones of mylonite gneiss in this area appear to have developed at a late metamorphic stage and are associated with small scale F_2 folding and transposition of gneissic fabric. These folds generally have shallow plunges to the northeast and southwest and are associated with a strong southeasterly plunging mineral lineation. In some areas, this lineation is the dominant penetrative fabric. The style of this second deformation strongly suggests that it was associated with northwesterly directed over-thrusting.

Several minor thrusts associated with F_2 folding have been observed at the base of reclined gabbro sheets in the southeastern part of the area. These are marked by progressive transposition of S_1 gneissic foliation into a flaggy S_2 mylonite fabric, then into ultra-mylonite and blastomylonite along the sole of thrusts.

Only one zone has been recognized which may represent a major thrust. This lies along the northern margin of the Unit 7 granite west of the Churchill River and is marked by a broad zone of intense mylonitization and foliation. The inferred thrust is drawn at the northerly limit of this deformation. Elsewhere in the map area, it appears that shortening has occurred along numerous minor thrust and ductile shear zones. This is particularly evident along the section provided by the Churchill River above its confluence with the Valley River. In this area, the Unit 6 quartz monzonite has been deformed by numerous closely spaced (50-100 m) mylonite and protomylonite zones which are separated by zones of weakly to moderately foliated quartz monzonite.

S_1 fabrics, F_2 fold axes, and thrusts have been refolded into north-south structural trends by an F_3 event that increases in intensity to the southeast. Numerous minor folds of north-south trend occur in the southeastern corner of the map area but, in general, it is uncertain whether these represent F_3 minor folds or rotated F_2 folds. The F_3 event does not appear to have been associated with the development of penetrative fabrics.

ECONOMIC GEOLOGY

Previous reports of mineralization in the area are restricted to a small occurrence of molybdenite in a gneiss boulder near Churchill Falls townsite (Callahan, 1969). The only mineral-

ization found during the present mapping was an occurrence of green beryl in pretectonic pegmatites in migmatitic gneisses 5 km northeast of Churchill Falls. The beryl is associated with tourmaline and occurs as crystalline aggregates up to 3 cm in diameter and as single crystals 1-2 cm long.

ACKNOWLEDGEMENTS

Able and willing assistance was provided by Keith Pike, Chris Ash and Bob McLachlan. Flying services were provided by John Innis of Universal Helicopters and logistical support by Wayne and E.J. Tuttle from Goose Bay.

Elmer Betts and the Churchill Falls (Labrador) Corporation are thanked for their valued assistance during the course of field work for the project.

REFERENCES

Barton, E.S. and Barton, J.M. Jr.
1970: Geological exploration in the Upper Churchill Watershed area. BRINEX private report, Toronto.

Brooks, C., Wardle, R.G. and Rivers, T.
in press: Geology and geochronology of Helikian magmatism, southwestern Labrador. Canadian Journal of Earth Sciences.

Callahan, J.E.
1968: Field report in the Upper Churchill area, Labrador. BRINEX private report, Toronto.

1969: Field report on the Upper Churchill area. BRINEX private report, Toronto.

1973: A regional heavy mineral petrographic and stream sediment geochemical survey applied to mineral exploration, Churchill Falls area, Labrador. Ph.D. thesis, Queen's University, Kingston, Ontario.

1980: Heavy minerals in stream sediments from Churchill Falls, Labrador - an aid in bedrock mapping. Canadian Journal of Earth Sciences, volume 17, pages 244-253.

Eade, K.E.
1952: Unknown River (Ossokmanuan Lake, east half), Labrador, Newfoundland. Geological Survey of Canada. Paper 52-9.

Greene, B.A.
1974: An outline of the geology of Labrador. Newfoundland Department of Mines and Energy, Mineral Development Divison, Information Circular No. 15.

Geological Survey of Canada aeromagnetic maps:
1972: Geological Survey of Canada, geophysical series (aeromagnetic) maps: 6064G, 6065G, 6066G.

Noel, N. and Rivers, T.
1979: Geological mapping in the McKay River - Gabbro Lake area, western Labrador. *In* Current Research. *Edited by* C.F.O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 214-221.

Wardle, R.J.
1979: Sandgirt-Gabbro Lake area, Labrador. Newfoundland Department of Mines and Energy, Mineral Development Division, Preliminary map with marginal notes, 7917.

White, M.V.
1968: Report on work done in the Churchill Falls area (Sept. 13th - Oct. 21st., 1968). BRINEX private report, Toronto.

REGIONAL GEOLOGY OF THE MICHIKAMAU LAKE MAP AREA, CENTRAL LABRADOR

by

G.A.G. Nunn

INTRODUCTION

1:100,000 mapping of the adjacent western corners of 1:250,000 NTS sheets 13E and 13L was commenced this summer and resulted in the completion of map areas 13E/13, 13E/14 and a part of 13L/3. These form the southern portion of a regional study located south and east of Michikamau Lake (now a part of the Smallwood Reservoir) which will be completed next year.

Access to the region is by tote road from Churchill Falls and crosses 13E/14. Mapping of the Michikamau Lake shore was performed by boat and that of the inland area by helicopter with some canoe and ground traverse backup. Exposure around the main lake shore, on several adjacent ridges, and around the edge and on islands within some of the inland lake basins is good. Inland, however, exposure is generally very poor and the terrain consists of an undulating plateau of extensive woodland with string bogs and moraine fields. Definition of geological contacts is therefore a major problem and many of those inland are very approximate.

PREVIOUS WORK

Early reconnaissance studies of parts of the area were made by Low (1895, 1897) and Thompson (1949, 1953) and were followed by Findlay (1957) and Sanderson and Jones (1958) who carried out follow-up studies to an airborne electromagnetic survey by the Labrador Mining and Exploration Company. Emslie (1964b, 1965, 1969, 1970, 1978) has extensively described the Michikamau anorthositic Intrusion which lies to the northwest of the area. A study of the metasedimentary units was included in this work (Emslie, 1970; 1978 and Emslie, in Wanless and Loveridge, 1978, pages 45-46).

The area is covered by the GSC 1:250,000 maps of Emslie (1964a) and Stevenson (1969) and also by a provincial compilation of the geology of Labrador at 1:1,000,000 by Greene (1972).

OBJECTIVES

The aims of the project were to elucidate the stratigraphy, structure and mineral potential of the area on a regional basis and in particular to:

(i) clarify the present confusion among the supracrustal sequences in the area;

(ii) map the extent of, and try to establish a stratigraphic and relative age framework for the Petscapiskau Group;

(iii) trace possible extensions of the Seal Lake Group westwards into the area in view of its potential for copper and uranium mineralization (Brummer and Mann, 1961; Gandhi and Williams, 1970; Marten and Smyth, 1975).

REGIONAL GEOLOGY

Previous work established the presence of three major lithological associations within the map area. A sequence of metamorphic rocks form the gneisses of the Churchill Province which are exposed in the northeastern part of the area. The igneous association is

made up of two units of Helikian plutonic rocks; the Michikamau anorthositic Intrusion in the northwest and a granitoid suite that underlies much of the southern portion of the area. Throughout the area various poorly defined supracrustal sequences of possible Aphebian, Helikian and Hadrynian age constitute the third association.

The major sedimentary sequence in the area has been referred to as the Petscapiskau Group. This group was named by Emslie (1970) from Petscapiskau Hill in 23I/8 and applied to other small areas of metasediment adjacent to the Michikamau Intrusion in 13L/4 and 13L/5 and regarded as Paleohelikian in age. The sequence was described as including paragneiss, schist, quartzite, metatuff and amphibolite, and their contact metamorposed equivalents. It was assumed to rest unconformably upon the gneisses and to be intruded by both Helikian plutonic suites. Emslie (1978) extended the group to include similar sequences in 13L/3. He suggested a tentative division of the group into a lower meta-aluminous sedimentary succession, and an upper volcanic or tuffaceous division. These he respectively correlated with the Aphebian Moran Lake Group and the Paleohelikian Bruce River Group of Smyth *et al*. (1975, 1978).

Green (1972) has also suggested that a large area of metasediment, previously assigned to the Seal Lake Group by Stevenson (1969), in the north of 13E/14 and which is contiguous with Emslie's extension in 13L/3, might also be equivalent to the Petscapiskau Group.

Also reported from the area was a sequence of younger sediments which were varyingly attributed to the Cambrian (Low, 1897), the Hadrynian (Stevenson, 1969), the Neohelikian or Hadrynian (Greene, 1972) and the Upper Proterozoic (Emslie, 1970). These occur in the west of the area, mostly on islands in Michikamau Lake.

This summer's work indicates that the earliest rocks, the gneisses of the Churchill Province, consist of an orthogneiss component (1c) emplaced into supracrustal (1a) or mafic intrusive (1b) rocks. These rock types were deformed during the Hudsonian orogeny and are therefore Aphebian or older. The orthogneisses are intruded by Helikian granitoid rocks (3) and overlain by the Seal Lake Group (5).

The type areas of the Petscapiskau Group, as defined by Emslie (1970), were not visited this year. The extensions of the group described by Emslie (1978) in 13L/3 and suggested by Greene (1972) in 13E/14 have been found to be largely underlain either by a part of the pre-Hudsonian supracrustal terrain (1a) or by Helikian granitoid rocks (3) respectively. Small occurrences of sediment (2) have been found in the latter area which may be equivalent to the Petscapiskau Group in its type areas (Emslie, 1970). For the present, however, their age and correlation is uncertain.

The Helikian granitoid suite (3) underlies the major part of the area and has been divided into a number of phases. Other Helikian intrusives are respresented by the gabbros and ultramafic rocks (4) which occur on two islands in Michikamau Lake and belong to the Michikamau Intrusion.

The younger sediments (6) of the western part of the area (13E/13 west) are believed to be of Neohelikian age and are correlated with the Seal Lake Group (5) which is exposed on the eastern margin of the area (13L/3).

UNIT DESCRIPTIONS

Unit 1 - Churchill Province Gneisses

These occur in the northern part of the area, mostly in 13L/3. Two components constitute the unit: a paragneiss and basic intrusive

LEGEND

NEOHELIKIAN

7 Diabase dikes

6 **Red Beds:** Medium to coarse grained, crossbedded, gray and red subarkosic and arkosic arenites with interbedded fine grained yellow sandstones, red siltstones, pebble to boulder conglomerates and minor slate

5 **Seal Lake Group:** Fine grained metabasic rocks interbedded with massive gray feldspathic quartzites

PALEOHELIKIAN

4 **Michikamau Intrusion:** Massive mafic gabbros and ultramafics with layered gabbro and leucogabbro and dikes of hornblendite and graphic granite

3 **Plutonic Suite**

3a **Ptarmigan Gabbro?** Equigranular medium grained leucogabbro

3b **North Pole Brook Intrusive Suite:** Gray granodioritic to quartz monzonitic suite (see Thomas, adjacent area)

3c Gray, medium grained diorite, quartz diorite and quartz monzodiorite ± scattered K-feldspar megacrysts. Probably equivalent to North Pole Brook Intrusive Suite

3d Pink weathering, gray, medium grained, plagioclase porphyritic quartz monzonite with scattered K-feldspar megacrysts

3e Undifferentiated; predominantly pink or red, medium grained, K-feldspar megacrystic quartz monzonite and adamelllite. Gradational into 3c, 3d, 3f and 3g

3f K-feldspar megacrystic rich quartz syenitic and granitic variety of 3e

3g Fine to medium grained, pink or buff predominantly non-porphyritic granites. Mostly strongly deformed

3h Fine to medium grained, pink, red and orange microgranites. Some porphyritic, many miarolitic and subaplitic

3i **Shabogamo Intrusive Suite:** Subophitic textured fine to medium grained gabbro

3j **Shabogamo Intrusive Suite?** Coarse grained plagioclase porphyry

Gabbro sheets (3i and 3j)

2 **Sediments of uncertain age:** Isolated outcrops and patches of dark gray cleaved or massive quartzite of unknown relationship to the plutonic rocks

APHEBIAN

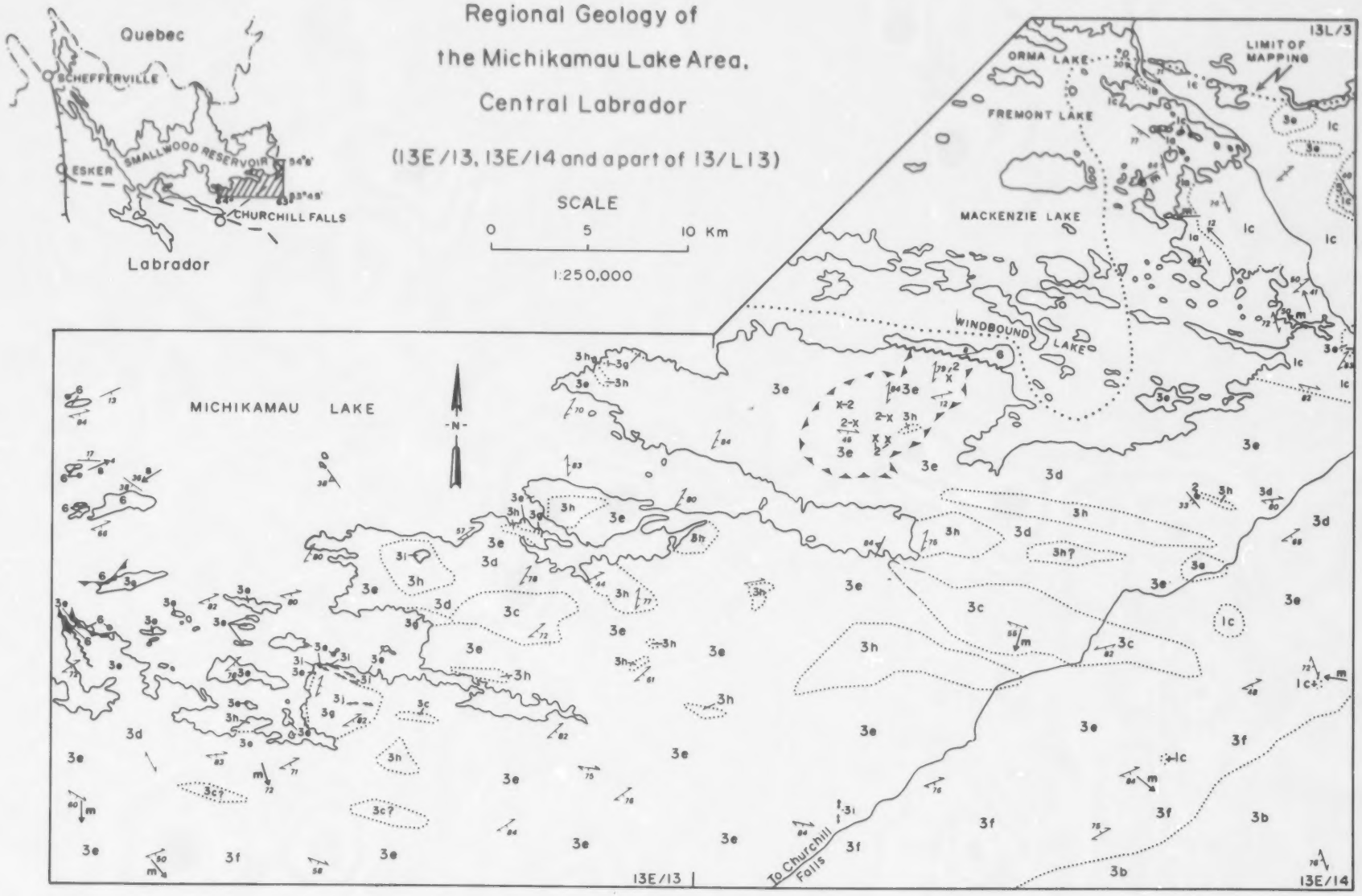
1 **Churchill Province gneisses**

1a Massive, fine to medium grained, hornblende porphyroblastic amphibolites and metagabbros; fine grained, banded amphibolites; fine grained tuffaceous? and semipelitic? paragneisses and minor sillimanite quartzites

1b Massive, medium to coarse grained, hornblende porphyroblastic amphibolites and ultramafics ± relict layering

1c Dioritic, tonalitic and granitic orthogneisses of pre- and synkinematic intrusion into 1a and 1b

NOTE: Unit subdivisions are not chronological.


Regional Geology of
the Michikamau Lake Area,
Central Labrador
(13E/13, 13E/14 and a part of 13/L13)
SCALE
0 5 10 Km
1:250,000
Quebec
SCHEFFERVILLE
ESKER
SMALLWOOD RESERVOIR
CHURCHILL FALLS
Labrador
13L/3
LIMIT OF MAPPING
ORMA LAKE
FREMONT LAKE
MACKENZIE LAKE
WINDBOUND LAKE
MICHIKAMAU LAKE
-N-
13E/13
To Churchill Falls
13E/14

association (1a, 1b) which was intruded pre- to syntectonically by a tonalitic to granitic plutonic suite (1c).

The main body of subunit 1a consists of concordantly interlayered banded amphibolites, tuffaceous and semipelitic paragneisses and minor sillimanite bearing quartzites which are intruded by massive amphibolites, locally containing relict igneous textures, and plagiophyric and amphibolite dikes. A small area north of Fremont Lake is composed of massive amphibolites and layered ultramafic rocks (1b).

The intrusive lithotypes represent a sequential plutonic event. This commenced with intrusion of hornblende-biotite tonalite into amphibolites and was followed by the sequential intrusion of early diorite, biotite ± hornblende tonalite (the most voluminous phase) and a later dioritic phase. This group was succeeded by a younger biotite-hornblende tonalite, an irregular, cream weathering felsic veining and a suite of crosscutting pink aplites, granites and pegmatites. The latter are probably coeval with granite and pegmatite net-veining seen in the small amphibolite/ultramafic body (1b). Amphibolite dikes cut the main tonalite and have been deformed with it. Much of this intrusive history has been established in a small area around Orma Lake but the early diorite and the main tonalite are recognizable in widely separate areas where exposure is good.

Orthogneisses also occur as inclusions in the plutonic suite in 13E/14 east.

Unit 2 - Sediments of Uncertain Age

This unit only occurs as a few isolated outcrops surrounded by unit 3. Those within the area of the thrust sheet in 13E/14 west are pale gray, feldspathic quartzites. The quartzites have been intercalated in imbricate fashion with tectonic slices of granitoid rocks. An exposure east of this locality, in 13E/14 east, is a massive, parallel laminated, dark gray quartzite.

Unit 3 - The Plutonic Suite*

This unit is a collection of variable plutonic lithotypes including gabbros and a range of intermediate to acid granitoid rocks. They are primarily grouped by spatial association and may belong to more than one intrusive episode.

An outcrop of leucogabbro (3a) is exposed by the roadside, in the centre of 13E/14 east. The gabbro is a medium to coarse grained equigranular aggregate of plagioclase with patches of disseminated ferromagnesian minerals. It is unlike other gabbros in the map area and has been provisionally correlated, on textural grounds, with the Ptarmigan Gabbro Suite of Thomas *et al.* (this volume) where its relationship to the surrounding granitoids is also uncertain.

A group of dioritic to quartz monzodioritic rocks (3b, 3c) outcrop in the southeast corner and across the centre of 13E/14, and as a number of smaller bodies throughout 13E/13. The diorite in the southeast (3b) is a gray-brown, medium grained rock and has only been observed at this one locality. The other rock types (3c) are white or gray plagioclase rich diorites and quartz diorites with elliptical clots of hornblende and biotite, minor amounts of pink intergranular, or gray porphyritic K-feldspar up to 0.5 cm in length, and color indices that are typically >10. Subunits 3b and 3c are correlated with

* Granitoid terminology used in this paper has been taken from the I.U.G.S. Subcommission recommendations, but is based on field identification only.

the more basic facies of the North Pole Brook Intrusive Suite in adjacent areas to the east (Thomas *et al.*, this volume).

Subunit 3c underlies topographically low-lying areas and lake basins with abundant lakeshore exposure, in contrast to subunit 3e which underlies higher areas, but is more poorly exposed. It is therefore possible to define the limits of subunit 3c more closely than the other members of unit 3. However, in outcrop the contact between 3c and 3e is usually either compositionally gradational or is marked by irregular changes in the K-feldspar megacryst content. The irregular changes take the form of dikes of 3e in 3c, of an interbanding, or of inclusions or schlieren of 3c in 3e. The inclusions may be the locus of magnetite concentrations.

The quartz monzonites (3e) contain similar proportions of palgioclase and K-feldspar, the former mainly as phenocrysts with scattered megacrysts and the latter as megacrysts and groundmass. Biotite is an additional phenocryst phase and the main primary ferromagnesian mineral. Hornblende is also present in some areas. Comspicuous magnetite grains, up to 7 mm across, are associated with the mafic minerals and may be locally concentrated.

The quartz monzonites (3e) are gradational into two other facies: 3d is a plagioclase porphyritic rock with minor indistinct K-feldspar megacrysts in a pink K-feldspar-quartz groundmass and probably ranges from quartz monzonite to quartz monzodiorite in composition; in contrast 3f contains an increased proportion of K-feldspar megacrysts and has a quartz syenite and syenite composition. Identification of 3f may be suspect in places due to reddening of plagioclase during deformation. 3d is abundant in northern areas of the plutonic suite while 3f is most common along the southern map boundary. These facies (3d, 3e, 3f) have a colour index of 2-8 and a quartz content of 10-25. Together they form the bulk of the suite in this map area.

In places fine to medium grained, commonly nonporphyritic granitic rocks are present (3g). These appear to be more quartz rich than the megacrystic rocks and are also more deformed, a feature which may obscure an originally porphyritic nature. The main plutonic phases are commonly cut by a suite of fine to medium grained granitic rocks (3h) ranging from small veins and dikes to large map-scale bodies. They are most abundant in the northwestern and northern parts of the unit. The medium grained parts of 3h are usually red or orange, recrystallized and contain scattered larger grains of quartz and feldspar. The microgranites may be miarolitic or seriate but are usually uniform, pink, and xenomorphic or sugary textured. Graphic granite or pegmatite dikes are associated with the aplites. Phases 3g and 3h have color indices of 0-2.

Fine to medium grained subophitic textured gabbros and leucogabbros (3i), which are correlated with the Shabogamo Intrusive Suite of southwestern Labrador (Wardle 1979c), are present in the southern and western parts of the map area within granitoid rocks of unit 3. They may be weakly banded or have a knobbly weathering texture due to grain size inhomogeneities. For the most part they occur as more or less tabular bodies and are presumed to be intrusive into the granitoid rocks. A body of similar tabular shape is a coarse (2-4 cm) plagioclase porphyry (3j) which occurs near the central eastern margin of 13E/13 west and is identical to the mafic porphyry of the Churchill Falls area (Unit 3, Wardle, this volume). This may also be associated with the Shabogamo Intrusive Suite.

Unit 4 - The Michikamau Intrusion

Lithologies belonging to this body were encountered on two small islands in Michikamau Lake in the northern part of 13E/13 east. They consist of layered leucogabbro and gabbro intruded by a hornblendite dike, successively overlain by massive mafic gabbros, ultramafic rocks and gabbros. The mafic gabbros

show some rhythmic variation. The ultramafics and gabbros are characterized by orthocumulate plates of orthopyroxene enclosing clinopyroxene ± olivine and plagioclase cumulus phases. Biotite is an abundant accessory, also usually occurring as orthocumulate plates. In places the sequence consists of gabbro blocks in a finer grained gabbro matrix. Igneous lamination is poorly developed but rhythmic layering and truncations indicate that the body youngs southwest.

These rocks are pyroxene rich, a feature which is unusual for the Michikamau Intrusion (Emslie, 1970) and possibly represent the transition from the banded border gabbro into the olivine gabbro-pyroxene troctolite sections of the "marginal zone" (Emslie, 1970). This would imply that the contact lies less than 500 m to the northeast of the islands (Emslie, 1970).

The relationship of the Intrusion to the plutonic suite is uncertain.

Unit 5 - Seal Lake Group

The only outcrop of this major Neohelikian sequence is found on the eastern edge of 13L/3 where it is continuous with the main Seal Lake Group outcrop area covering large parts of 13L and 13K. The unit consists of a succession of pale gray, planar bedded, feldspathic quartzites and arkoses interbedded with fine or medium grained brown weathering metabasic rocks. This association suggests a correlation with the Bessie Lake Formation of the Lower Seal Lake Group of Robinson (1954) and Mann (1959).

Unit 6 - Red Beds

These outcrop on the southern shore of Windbound Lake (13E/14 west) and on islands in Michikamau Lake (13E/13 west). The sequence on the islands is composed mainly of red and pale gray, medium to coarse grained, crossbedded, subarkosic and arkosic arenites. These are interbedded with finer grained yellow sandstones and red siltstones. Minor lithologies include granule and boulder conglomerates and purple mudstones (slates). Bedding is tabular and channel forms are rare. The arenites are clean and well sorted and occur in massive or single set crossbedded sheets 10-40 cm thick (co-sets rare). Most current directions from foresets and ripple marks are towards the southwest quadrant. Load structures and small scale scours of an overlying bed into the oxidized top of an underlying one are common. South of Windbound Lake the arenites are of the same facies. The siltstones are parallel laminated, thinly bedded and disrupted by mudcracks and sand dikes. The conglomerates are rounded, well sorted and clast supported. The finer granule-pebble conglomerates are dominated by quartzite with chert and acid volcanic clasts. Some of these granule conglomerates and matrix supported pebbly sandstones contain granitoid, volcanic porphyry and large K-feldspar clasts. A single, boulder conglomerate horizon, more than 20 m thick, consists almost exclusively of feldspar porphyritic volcanic clasts with about 10% microgranite (typical of 3h) and minor sedimentary clasts.

The red beds are inferred to lie unconformably upon the plutonic suite due to the presence of granitoid and K-feldspar clasts in the conglomerates. The preponderance of volcanic porphyry over granitoid clasts and of microgranite (3h) over coarser grained granitoid types (*e.g.* 3e) suggests that this part of the red bed sequence is the product of erosion of a relatively high, subvolcanic level of the plutonic suite. However, the red beds have been seen only in fault contact with the granitoid rocks. South of Windbound Lake the fault is thought to be steep but in the western area a thrust contact has been seen at three localities and this displacement occurs prior to the main deformation. These stratigraphic and structural relationships are similar to those recognized between the Seal Lake Group and the plutonic suite to the east of this map area (*e.g.* Marten, 1975; Thomas 1979).

These rocks are interpreted as possible intertidal sediments deposited marginal to an arid landmass.

Red beds are present throughout the Seal Lake Group succession in the 13L east map area (Roscoe and Emslie, 1973) but are more prevalent towards the top of the sequence. Elsewhere in the sequence they occur interbedded with other rock types. The red beds of this area are therefore tentatively correlated with the upper parts of the Seal Lake Group elsewhere.

Unit 7 - Diabase Dikes

Several diabase dikes cut the plutonic suite. They vary from medium grained and ophitic textured to fine grained, cleaved, feldspar phyric rocks.

Pleistocene

The Pleistocene deposits unconformably overlie all other units and consist of a coarse clastic sequence (which follows the outline of the present lake basin in distribution), and an extensive glacial cover.

STRUCTURE AND METAMORPHISM

The map area has been affected by two orogenic episodes; the Hudsonian, *ca.* 1750 Ma, and the Grenville, *ca.* 1000 Ma.

The Hudsonian orogeny affected only unit 1 and resulted in a dominantly north-northwesterly structural grain in the unit which is due to the subparallel orientations of subunits 1a and 1c at map scale and the banding and fabric at outcrop scale. The early diorite contains a migmatitic banding which was cut by the main tonalite and its associated veins. The tonalite has a more poorly developed or incipient banding. Where the banding in the tonalite is more pronounced it may have been folded several times and refolded. The fabric is axial planar to the earlier folds.

Though interference folds in the migmatites and in some thinly banded paragneisses indicate several deformations there is only one major fabric development. The paragneiss association and the earlier group of intrusives contain a strong penetrative fabric. Some massive amphibolites and the later intrusives have only a weak or zonal fabric development which may indicate synkinematic intrusion for these rocks. The rocks are LS tectonites with a strong west to northwest plunging rodding that may well have transposed any earlier fabrics.

Accompanying metamorphism was at amphibolite facies and probably peaked fairly late during the fabric generation.

A host of small, variably oriented, dextral and sinistral shear zones, with small scale displacements, deflect the fabrics in the gneisses. Also the main structural trend was reorientated into an approximately east-southeast direction on the short limbs of a later asymmetric folding which plunges north-northwest. These folds occur at outcrop scale in the gneisses and as crenulations in some amphibolites but have no associated mineral growth.

Hudsonian textures and fabric elements are also preserved in gneiss inclusions in the plutonic suite (13E/14 east).

The effects of the Grenville orogeny are most clearly developed in the plutonic and sedimentary rocks of the southern part of the area. The rocks of units 1, 3, 5 and 6 in the north are relatively undeformed by this orogeny. However, the southernmost pluton of unit 3 emplaced into the gneisses has a well developed early Grenville fabric (see below). The effects of Grenvillian deformation on the gneisses are not known due to lack of exposure. It appears, therefore, that the northern limit of major ductile Grenville deformation lies somewhere in the region of Windbound Lake and trends more or less east-west.

An early Grenville fabric is seen in the northern part of the plutonic suite where it is developed as an SL mineral alignment in 3d and 3e, a shape fabric in 3g and a mineral fabric or fracture cleavage in 3h. This fabric strikes north-northeast, is subvertical and usually weak in the megacrystic granitoids but stronger in the finer grained rock types.

This period of early fabric development was followed by northerly directed overthrusting on shallow south dipping planes. In the north of map sheet 13E/14 west this has produced a klippe of granitoid rocks with isolated intercalations of sediment. Structures related to thrusting in this klippe are seen as south dipping zones of fracture cleavage in the granitoid lithotypes (3d, 3e) and as a penetrative mineral fabric in the quartzites (2). The thrust and the related structures are gently warped, possibly as a result of the later, main deformation. Locally this period of thrusting produced mylonites; as in 13E/13 west where the granitoid rocks were thrust over the red beds (6).

The early fabric has been reorientated into the predominant east-northeast Grenville structural trend during a later period of northerly directed ductile overthrusting characterized by steep, south-southeast dipping foliation surfaces. In the more strongly deformed rocks superimposition of the two deformations resulted in an LS shape fabric with a down dip lineation to the south-southeast. To the north of the unit 3 outcrop area this dominant Grenville fabric is localized into discrete shear zones. This inhomogeneity is reflected in the main body of subunit 3c (central 13E/14) where the northwestern part is only weakly deformed by the early fabric while the remainder contains a good mineral lineation or shape fabric related to the main deformation. The shear zones become increasingly pervasive towards the south of the area and much of the southern and south-eastern portions of the area are underlain by homogeneous strongly foliated granitoids (3e, 3f).

The mylonitized granitoid rocks and red bed sequences were deformed together during the main deformation episode. Throughout the island outcrops of unit 6, this deformation produced a grain elongation mineral fabric in the arenites, a pressure solution striping in the finer grained yellow sandstones, a penetrative cleavage in the mudstones (now slates), and a flattening of clasts in the conglomerates.

Late structures throughout the southern area include undulose warping of the main fabric, east-west orientated steeply north dipping shear zones with a downthrow to the north, and a transcurrent sinistral shear zone striking about 025.

Brittle fractures with significant displacements follow trends 110 and 150. Both are steep but the displacement vector within the fault planes is unknown. The former fracture trend is seen as the fault between units 3 and 6 south of Windbound Lake, and probably has a considerable vertical component with downthrow to the north. This fracture trend may also include a possible fault contact between units 1 and 3.

The Grenvillian deformation occurred under greenschist facies conditions. Effects related to the fabric developments are seen as partial to more complete chloritization of biotite in the early and main fabrics respectively. The deformed gabbros show linear mineral fabrics defined by fine grained amphibole and plagioclase, and the granitoid lithotypes contain the predominant assemblage K-feldspar + Na-plagioclase + quartz + chlorite + epidote + hematite. The mineralogy in the sediments is little changed except for recrystallization of phyllosilicates in argillaceous rocks.

ECONOMIC GEOLOGY

A hand held scintillometer survey failed to reveal anomalous radioactivity in any of the map units. Magnetite is rarely present as clustered crystal concentrations in the granitoid and gabbro lithotypes. A few grains of molybdenite were found in the granitic net veins in the small area of 1b near Fremont Lake. Pyrite in insignificant amounts is disseminated throughout the basic rocks of the area and also occurs in vugs and thin alteration zones within the granitoid rocks. A locality containing minor fluorite and also one bearing secondary muscovite alteration were found in unit 3.

ACKNOWLEDGEMENTS

I wish to thank Wayne Eurglunes and Keith Pike for help in the field and W. Tuttle and Universal Helicopters for logistical assistance. Dick Wardle critically reviewed the manuscript.

References

Brummer, J.J. and Mann, E.L.
1961: Geology of the Seal Lake area, Labrador. Geological Society of America Bulletin 72, pages 1361-1382.

Emslie, R.F.
1964a: Kasheshibaw Lake, west half, Newfoundland-Quebec. Geological Survey of Canada, Map 3-1964.

1964b: Potassium-argon age of the Michikamau Anorthositic Intrusion, Labrador. Nature 202, pages 172-173.

1965: The Michikamau Anorthositic Intrusion, Labrador. Canadian Journal of Earth Sciences, Volume 2, pages 385-399.

1969: Crystallization and differentiation of the Michikamau Intrusion. *In* Origin of anorthosite and related rocks. *Edited by* Y.W. Isachsen. New York State Museum, Memoir 18, pages 163-173.

1970: The geology of the Michikamau Intrusion, Labrador (13L, 23I). Geological Survey of Canada, Paper 68-57, 85 pages.

1978: Elsonian magmatism in Labrador: age, characteristics and tectonic setting. Canadian Journal of Earth Sciences, Volume 15, pages 438-453.

Findlay, D.C.
1957: Primary anomaly evaluation, Windbound Lake - Gabbro Lake area. Unpublished private report for Labrador Mining and Exploration Company.

Gandhi, S.S. and Williams, M.
1970: Economic potential of the central Labrador mineral belt. Unpublished private report G70012, BRINEX LTD.

Greene, B.A.
1972: Geological map of Labrador. Newfoundland Department of Mines, Agriculture and Resources, Mineral Resources Division.

Low, A.P.
1895: The Labrador peninsula - SE. Geological Survey of Canada, Map.

1897: Report on exploration in the Labrador peninsula along the East Main, Koksoak, Hamilton, Manicouagan and portions of other rivers in 1892-93-94-95. Geological Survey of Canada, Annual Report Number 8 (L), page 223.

Mann, E.L.
1959: The geology of the Seal Lake area, Central Labrador. Unpublished Ph.D. thesis, McGill University.

Marten, B.E.
1975: Geology of the Letitia Lake area, Labrador. *In* Report of Activities for 1974. *Edited by* J.M. Fleming. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 75-1, pages 75-85.

Marten, B.E. and Smyth, W.R.
1975: Uranium potential of the basal unconformity of the Seal Lake Group, Labrador. *In* Report of Activities for 1974. *Edited by* J.M. Fleming. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 75-1, pages 106-115.

Robinson, W.G.
1954: Exploration of the Seal Lake Concession, Labrador. Unpublished private report, Frobisher Ltd.

Roscoe, S.M. and Emslie, R.F.
1973: Kasheshibaw Lake (east half), Newfoundland-Quebec. Geological Survey of Canada, Map 1342A.

Sanderson, G.S. and Jones, J.L.
1958: Final report of fieldwork June 22 - August 3, 1957. Unpublished field report for Labrador Mining and Exploration Company.

Smyth, W.R., Marten, B.E. and Ryan, A.B.
1975: Geological mapping in the Central Mineral Belt, Labrador: Redefinition of the Croteau Group. *In* Report of Activities for 1974. *Edited by* J.M. Fleming. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 75-1, pages 51-74.

1978: A major Aphebian-Helikian unconformity within the Central Mineral Belt of Labrador: Definition of new groups and metallogenic implications. Canadian Journal of Earth Sciences, Volume 15, pages 1954-1966.

Stevenson, I.M.
1969: Lac Brûlé and Winokapau Lake map-areas, Newfoundland and Quebec (13D, 13E). Geological Survey of Canada, Report 67-69 (incorporating map 27-1967), 16 pages.

Thomas, A.
1979: Geological mapping in the Red Wine Lake - Letitia Lake area (13L/1, 13L/2, 13L/8), Central Labrador. *In* Report of Activities for 1978. *Edited by* R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 79-1, pages 109-114.

Thomas, A. Jackson, V. and Finn, G.
1981: Geology of the Red Wine Mountains and surrounding areas. This volume.

Thompson, A.R.
1949: Geological reconnaissance east of Michikamau Lake, Labrador. Private report, Labrador Mining and Exploration Company.

1953: The reconnaissance geology of the south Michikamau Lake area. Private report, Labrador Mining and Exploration Company.

Wanless, R.K. and Loveridge, W.D.
1978: Rubidium-strontium isotopic age studies, Report 2 (Canadian Shield). Geological Survey of Canada, Paper 77-14, 70 pages.

Wardle, R.J.
1979c: Geology of the Sandgirt - Gabbro Lake area. Newfoundland Department of Mines and Energy, Mineral Development Division, Preliminary map 7917 with marginal notes.

Wardle, R.J. and Britton, J.
1981: Regional geology of the Churchill Falls area. This volume.

GEOLOGICAL MAPPING IN THE ASHUANIPI LAKE - LAC PETITE-HERMINE AND RANNIE LAKE AREAS, WESTERN LABRADOR

by

T. Rivers

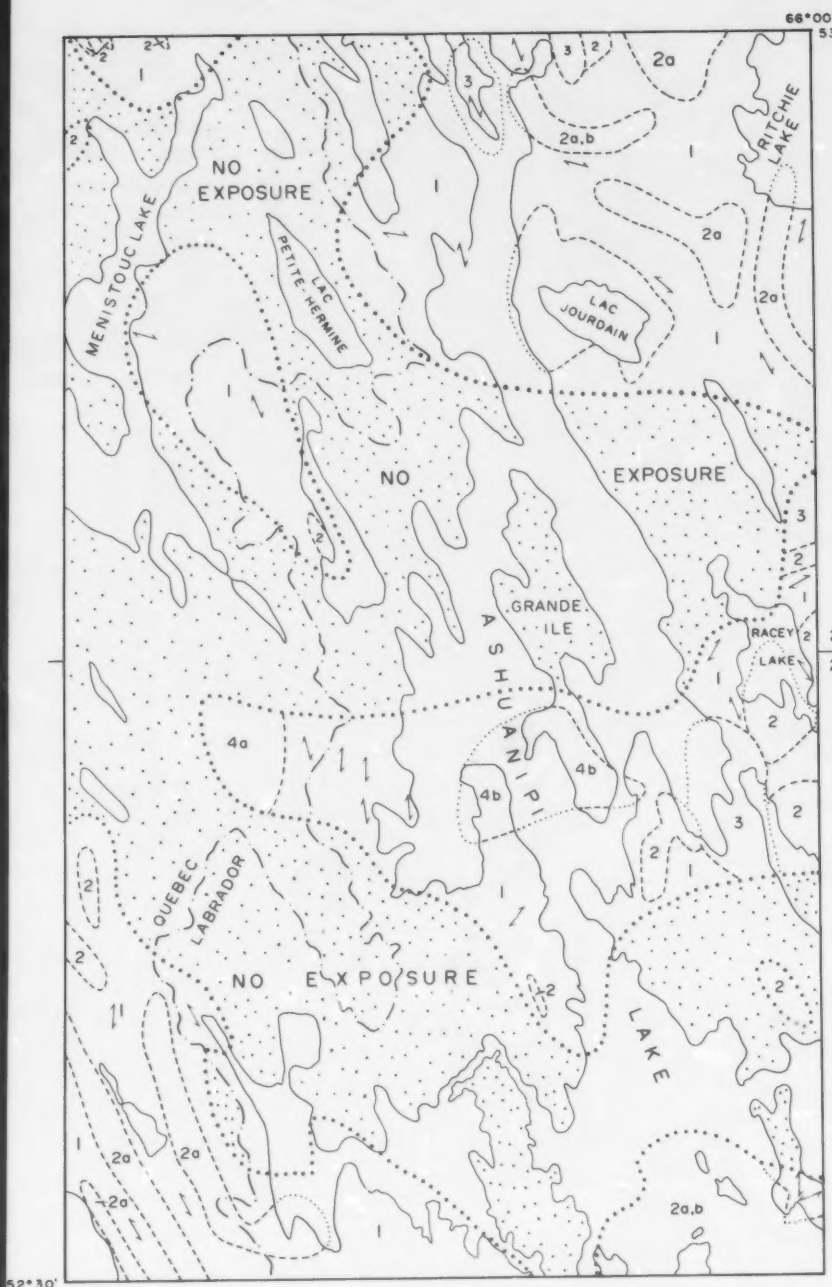
INTRODUCTION

The Ashuanipi Lake (23B/9) - Lake Petite-Hermine (23B/16) area (Figure 1) was mapped at 1:100,000 reconnaissance scale by helicopter during the early part of the summer of 1980, thus completing coverage of the four 1:50,000 map sheets comprising 23B(NE). Additionally some helicopter supported mapping was done in the Rannie Lake area (23G/10, Figure 2) and limited work was also done in the Wightman Lake (23G/1), Molson Lake (23G/8) and Gabbro Lake (23H/11) map areas, which were covered during the 1979 season. Samples for radiometric dating were collected in the Lac Petite-Hermine and Wightman Lake map areas.

GENERAL GEOLOGY

The Ashuanipi Lake - Lac Petite-Hermine map area lies within the Grenville Province, some 50 - 150 km south of the Grenville Front Tectonic Zone (terminology of Wynne Edwards, 1972). Bedrock is principally composed of quartzofeldspathic-pelitic schists and gneisses believed to be part of the Attikamagen Formation, the lowest unit of the Aphebian Knob Lake Group in the Grenville Province (Rivers, 1978, Rivers and Massey 1979, Rivers 1980c). However, the distinctive, overlying platformal sequence of the Knob Lake Group including dolomitic marble, quartzite and iron formation has not been found in the map area, and it is also possible that the schists and gneisses at least in part represent the Menihek Formation, a younger shale unit which overlies iron formation in the Knob Lake Group stratigraphy of the Labrador Trough. In view of the uncertainty, however, this unit is referred to as the Attikamagen Formation here. Intrusive into these schists and gneisses are a large number of gabbroic and granitoid intrusions, interpreted to be of Helikian age. The gabbros are considered to be part of the Shabogamo Intrusive Suite (Rivers 1980b). Some of the granitoid rocks may also belong to this suite, but the affiliation of other bodies is not well known, nor is the relative timing of emplacement of the gabbroic and granitoid rocks.

The Rannie Lake area lies more than 100 km north of the Ashuanipi Lake - Lac Petite-Hermine area, and spans the junction between the Superior and Churchill tectonic provinces. Mapping in this area was restricted to the contact region along the border between the two provinces, where gneisses of the Archean Ashuanipi Metamorphic Complex in the Superior Province are unconformably overlain by quartzite, iron formation, and slate of the Wishart, Sokoman and Menikek Formations respectively of the Knob Lake Group. Although no exposures of the unconformity were found, its position can be defined to within 200 m or so in several places.



SYMBOLS

Geological boundary (approximate, assumed)

Limit of areas of exposure

Provinical boundary

Trend of foliation

HELIKIAN

4 GRANITOID INTRUSIVES
4a, adamellite, 4b, porphyritic granodiorite

3 SHABOGAMO INTRUSIVE SUITE
diorite

2 2a gabbro, 2b peridotite

APHEBIAN KNOB LAKE GROUP

1 ATTIKAMAGEN FORMATION-
quartzo, feldspathic and pelitic schists and gneisses

FIGURE 1

ASHUANIPI LAKE (23B/9) and LAC PETITE-HERMINE (23B/16)

PREVIOUS WORK

In the Ashuanipi Lake - Lac Petite-Hermine area previous mapping is limited to the work of Newfoundland and Labrador Corporation (Wall, 1953) at 1 inch to 1/2 mile scale in the north east corner of the Ashuanipi Lake area, and the regional reconnaissance survey by the Geological Survey of Canada at 1:125,000 scale (Jackson, 1976).

The Rannie Lake area has been previously mapped in part, at 1 inch to 1/2 mile scale, by the Iron Ore Company of Canada (Tiphane, 1951) and is also covered by the Geological Survey of Canada regional maps at 1 inch to 4 mile scale by Fahrig (1967).

ASHAUNIPI LAKE - LAC PETITE-HERMINE AREA

DESCRIPTION OF UNITS

Attikamagen Formation (Unit 1)

The Attikamagen Formation is typically composed of banded, biotite bearing quartzofeldspathic or pelitic schist/gneiss, with muscovite, K-feldspar, garnet, sillimanite or kyanite being additional significant phases locally. The compositional banding, which may be on a metre scale or greater, is not always apparent in small outcrops; where present, however it is generally parallel to S_1 the regional foliation defined by micas and other minerals, indicating that the unit has been penetratively folded and deformed. Locally, however, outcrops in which S_0 is not parallel to S_1, have been found, which are interpreted to be situated in fold hinges.

Metamorphic mineral assemblages in the Attikamagen Formation suggest that metamorphic grade increases towards the east, a trend that has also been reported in the adjacent area to the north (Rivers 1980a). Kyanite is present in pelitic horizons in the west of both map areas, and is replaced by sillimanite in the east. Kyanite and fibrolitic sillimanite were found together in a thin section of a specimen from the east shore of Menistouc Lake. Muscovite is also present in the rock, and microstructural relations indicate that sillimanite is replacing kyanite. Furthermore, muscovite and quartz occur in the west of the map area, and are replaced by the equivalent mineral pair aluminum silicate - K-feldspar in the east. In the north of the Ashuanipi Lake map area, near the Labrador-Quebec border, the assemblage quartz-kyanite-biotite-plagioclase-garnet-magnetite-K-feldspar-muscovite (ragged and out of equibrium) was observed, whereas in the northeast of the Lac Petite-Hermine map area the equivalent assemblage is quartz-sillimanite-biotite-plagioclase-garnet-magnetite-perthite. Granitic veins and sweats are common throughout the map area in the Attikamagen Formation; they are typically small, discrete features parallel to the regional foliation (S_1), and have been described as lit-par-lit migmatites elsewhere (Rivers (1978).

The Attikamagen Formation is considered to be predominantly sedimentary in origin (Rivers, 1978) and probably represents a thick graywacke-shale sequence. At high metamorphic grades, however, it is difficult to distinguish metasedimentary from metaigneous rocks of similar composition, especially in areas of poor exposure, and some granitic sills and other small intrusions may be incorporated in the unit.

Shabogamo Intrusive Suite (Units 2 and 3)

Metagabbro, amphibolite and metapyroxenite (Unit 2)

The predominant lithology of the Helikian Shabogomo Intrusive Suite is massive to foliated, coarse grained metagabbro and subordinate amphibolite (Unit 2a). In most exposures the composition was noted as leucogabbroic, with plagioclase feldspar composing 60%

or more of the rock. Relict subophitic igneous textures are visible in many of the specimens, although in a few of the more deformed examples this is partially to completely obliterated by the tectonic foliation and amphibolite mineralogy. Metamorphic corona structures composed of colourless to green amphibole, garnet and less commonly biotite are ubiquitous, and frequently visible to the naked eye. They are interpreted to be due to reaction between primary plagioclase feldspar and mafic minerals (olivine, ortho-and clino-pyroxene and opaques) during metamorphism and partial hydration of these dry rocks (Rivers, 1980a). Ultramafic lithologies (Unit 2b) were noted in a few localities - these metapyroxenites, which are composed of orthopyroxene, clino-pyroxene, hornblende and minor carbonate, may represent basal cumulate units in some of the layered intrusions.

Although in this area of poor exposure, field relationships are difficult to determine in detail, the outline of the various bodies of gabbro in relation to the regional foliation suggests that many of them have the form of sills and thick sheets, especially in the southwest of the Ashuanipi Lake area. In the east of the map area two bodies have curved outlines at high angles to the regional strike, and may be situated in fold hinges. Stock-like forms are indicated by the shapes of some of the intrusions near the northeast corner of the Lac Petite-Hermine map area, a feature which is consistent with observations made elsewhere (Rivers, 1980a). Sills and sheets appear to be the typical mode of emplacement near the Grenville Front Tectonic Zone, with stocks becoming more common in the interior Grenville Province.

Many of the gabbroic bodies are associated with a characteristic high magnetic signature, which has enabled them to be traced through regions of poor exposure.

Metadiorite (Unit 3)

The several intrusions of diorite which have been recorded in the map area show some variation in composition, though it is probable that they are all genetically related. These rocks are typically grayish with grain size varying from coarse to fine. The most common mafic minerals are biotite and hornblende, but many of the specimens examined also contain clinopyroxene and more rarely orthopyroxene (hypersthene), with the latter two minerals showing signs of replacement by the former. Relict plagioclase phenocrysts (composition not determined) are visible in some of the specimens, but quartz has not been observed. Several bodies contain rounded inclusions 1 cm to 1 m in diameter of more mafic igneous rocks, which generally show sharp contacts with their host. A "Neohelikian" basic metavolcanic mapped by Jackson (1976) appears to be fine grained diorite

Several features suggest that the metadiorites are genetically associated with the metagabbros of Unit 2, and therefore should be included within the Shabogamo Intrusive Suite. The two lithologies are frequently closely associated in the field, and the presence of clinopyroxene and orthopyroxene in the metadiorite invites comparison with these minerals in the metagabbro. Microchemical analyses of pyroxenes from both lithologies are required to confirm this hypothesis. Lastly, the mafic enclaves in the metadiorite are gabbroic in composition, and resemble fine grained gabbro of the Shabogamo Intrusive Suite north of the map area (Rivers, 1980a). This suggests that the two magmas were intimately associated, with the metadiorites being either a younger differentiate or a hybrid contaminated rock. Geochemistry is needed to resolve this problem.

Granitoid Intrusions (Unit 4)

Two distinct types of granitoid rocks occur in the map area, which are grouped together as Unit 4 in this report.

Unit 4a is an adamellite or type 3b granite in the terminology of Streckeisen (1976). It was observed at the south end of Menistouc Lake near the Labrador - Quebec border, where it is a medium to coarse grained, leucocratic, weakly foliated rock consisting of plagioclase and K-feldspar in approximately equal proportions, quartz, biotite and minor muscovite and magnetite. A weakly developed gneissic layering is seen in some outcrops. An interesting feature of one of the outcrops is the presence of small, coarse grained elongate inclusions of biotite, garnet and kyanite and numerous coarse grained pegmatitic sweats, both of which are aligned approximately north/south parallel to the regional foliation. The pelitic inclusions are presumably derived from the Attikamagan Formation, and their refractory composition suggests that there may be a genetic association between the two units, and that Unit 4a is an S-type granitoid (terminology of Chappell and White, 1974).

Unit 4b, metamorphosed porphyritic granodiorite is exposed at the south end of Grande Ile in Ashuanipi Lake. Phenocrysts of microcline and zoned plagioclase feldspar up to 6 cm long are aligned in a strongly foliated matrix of ribbon quartz, feldspar and biotite with minor magnetite. Large poikilitic crystals of sphene, locally associated with garnet and apatite, are also a feature of this unit. The relationship of Unit 4b with Unit 4a or the Shabogamo Intrusive Suite (Units 2 and 3) is not known, but the presence of a foliation in the unit indicates that it was emplaced prior to the Grenvillian Orogeny.

STRUCTURAL GEOLOGY

Structural trends in the area are predominantly north to northwest, with a few measurements being at high angles to these directions. These are interpreted to be the locations of fold closures in a region of tight to isoclinal folding.

Comparison of the structural pattern with that mapped in areas to the north and northeast (Rivers, 1978; 1980a; 1980c) suggests that these interpreted fold closures are the regional F_3 structures, which here, as elsewhere, do not have a penetrative axial planer fabric associated with them. The foliation and subparallel compositional layering which is folded by the F_3 folds is considered to be a D_1 feature. Regional D_2 structures have not been observed in the map area, and it appears that these may be developed mainly in the Grenville Front Tectonic Zone (Rivers, 1978; 1980c; Rivers and Massey, 1979).

METAMORPHISM

Schists and gneisses in the Attikamagen Formation of pelitic composition furnish several indications of the grade of metamorphism during the Grenvillian Orogeny. The presence of kyanite in the west of the map area indicates that pressures were above the aluminum silicate triple point, and occurrences of sillimanite in the south and east of the map area indicate that metamorphic grade was increasing in that direction (*i.e.* towards the interior Grenville Province). The disposition of the kyanite - sillimanite isograd appears to be a rather wavy line, but may trend approximately northeast.

The presence of the mineral pair, muscovite + quartz, in the west of the map area, and the equivalent mineral pair, aluminum silicate + K-feldspar, in the east is another useful metamorphic indicator, in particular since both aluminum silicates (kyanite and sillimanite) were observed to coexist with K-feldspar. These observations pinpoint the P-T conditions on a petrogenetic grid quite precisely, as the position where the steep positive slope of the muscovite (in the presence of quartz) breakdown reaction intersects the more gentle slope of the kyanite - sillimanite reaction. Inspection of the theoretically and experimentally

calibrated P-T grid of Hess (1969) suggests that pressures were 6-7 kb and temperatures were 700 - 750°C during the Grenville Orogeny.

ECONOMIC GEOLOGY

No showings of economic interest were observed in the map area. Concentrations of magnetite occur in gabbro of the Shabogamo Intrusive Suite, but these are thought to be of insufficient size to warrant follow-up investigations.

RANNIE LAKE AREA

DESCRIPTION OF UNITS

Ashuanipi Metamorphic Complex (Unit 1)

The Archean Ashuanipi Metamorphic Complex is composed of a banded migmatitic gneiss of granodioritic to dioritic composition, similar to that mapped further south (Rivers and Massesy, 1979; Rivers, 1980c). Bands, lenses and boudins of foliated dioritic gneiss are typically included in pyroxene bearing granitic rocks with igneous textures.

Knob Lake Group (Units 2 - 4)

In the boundary region with the Ashuanipi Metamorphic Complex, only the upper part of the Knob Lake Group, *i.e.* the Wishart, Sokoman and Menihek Formations, is present.

Wishart Formation (Unit 2)

The Wishart Formation was found in a single large outcrop close to the anticipated position of the Archean - Aphebian unconformity. In this locality it is predominantly composed of a coarse conglomeratic quartzite (granule conglomerate), which is essentially of identical composition to the underlying gneisses. Clasts consist of single grains and small grain aggregates of gneissic material, and at first glance the lithology appears similar to the gneisses themselves. Prominent features include blue quartz pebbles and feldspar phenoclasts up to 3 cm in size derived from the coarse grained leucocratic phase of the basement gneisses. The thickness of the conglomeratic quartzite unit could not be measured in the field, but it is unlikely to exceed 20 m.

The local provenance and thin vertical extent of this unit suggest that it may be infilling depressions on an irregular unconformity surface, and thus is not everywhere present. If this is the case, the younger Sokoman Formation may have locally onlapped over the Wishart Formation onto the basement.

Sokoman Formation - Unit 3

The Sokoman Formation is principally composed of carbonate and cherty carbonate iron formation in this area. Carbonate iron formation weathers a characteristic orange-red colour, rendering the unit highly distinctive. Massive chert beds are commonly interlayered with the carbonate, and these have recrystallized to quartzite; carbonate pisoliths in a cherty quartzite matrix have been observed in some outcrops. Magnetite and hematite rich layers occur locally, and the unit as a whole has a strong magnetic signature. Although outcrop distribution is poor, it appears that iron oxides become more abundant away from the unconformity, suggesting that the lower iron formation lithologies are predominantly of the cherty carbonate variety.

Many outcrops show evidence of leaching and secondary mobilization of iron and manganese oxides, which by analogy with similar alteration elsewhere, probably took place in the Cretaceous (see Rivers, 1978).

Menihek Formation (Unit 4)

The Menihek Formation is composed of featureless gray slate in this area, with S_0 compositional layering subparallel to S_1 slaty cleavage in some

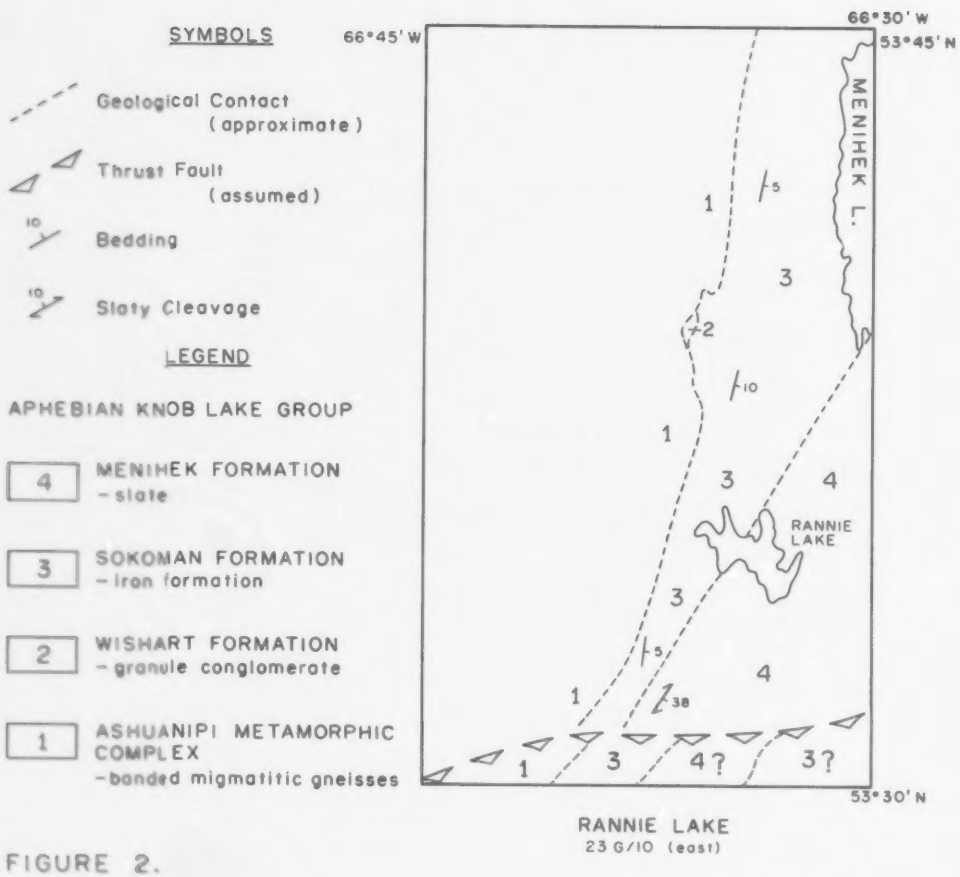

SYMBOLS
Geological Contact (approximate)
Thrust Fault (assumed)
Bedding
Slaty Cleavage
LEGEND
APHEBIAN KNOB LAKE GROUP
4 MENIHEK FORMATION - slate
3 SOKOMAN FORMATION - iron formation
2 WISHART FORMATION - granule conglomerate
1 ASHUANIPI METAMORPHIC COMPLEX - banded migmatitic gneisses
66°45' W
66°30' W
53°45' N
53°30' N
MENIHEK L.
RANNIE LAKE
RANNIE LAKE
23 G/10 (east)

FIGURE 2.

outcrops, but discordant in others. Locally, small non-penetrative F_2 folds with northeast to easterly trends and steep axial surfaces were seen.

STRUCTURAL GEOLOGY AND METAMORPHISM

With the exception of the Menihek Formation, the Aphebian units appear undeformed. The Menihek Formation, however, which is exposed in the south of the map area, carries the imprint of two deformations which are interpreted to be of Grenvillian age. S_1 slaty cleavage is a penetrative feature, whereas F_2 folds and crenulations are nonpenetrative; similar relationships were observed in the map area to the south (Rivers 1980d). These fabrics occur over 30 km north of the previously known northerly limit of Grenvillian deformation.

Grenvillian metamorphism in the map area is of very low grade. Quartz in iron formation has recrystallized, and the slate of the Menihek Formation consists of very fine grained, quartz-muscovite-feldspar slates with opaques (including graphite) disseminated along slaty cleavage planes.

ECONOMIC GEOLOGY

The four lithologies in the map area are not considered to have economic potential; iron formations present are of lower grade and thinner than elsewhere in the Labrador Trough.

ACKNOWLEDGEMENTS

Baxter Slade ably piloted the helicopter and was a good companion in the field. Wayne Tuttle commanded operations from Goose Bay. Discussions with Richard Wardle, who also accompanied the author on the Rannie Lake traverse, were most helpful.

REFERENCES

Chappell, B. W. and White, A. J. R.
1974: Two contrasting granite types. Pacific Geology, Volume 8, pages 173-174.

Fahrig, W. F.,
1967: Shabogamo Lake map area, (23G/E 1/2), Newfoundland/ Labrador and Quebec. Geological Survey of Canada, Memoir 354.

Hess, P. C.
1969: The metamorphic paragenesis of cordierite in pelitic rocks. Contributions to Mineralogy and Petrology, Volume 24, pages 191-207.

Jackson, G. D.
1976: Opocopa Lake map sheet, (23B/E 1/2), Quebec - Newfoundland. Geological Survey of Canada.

Rivers, T.
1978: Geological mapping in the Wabush-Labrador City area, southwestern Labrador. *In* Report of Activities, for 1977. *Edited by* R. V. Gibbons, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 78-1, Pages 44-50.

1980b: Revised stratigraphic nomenclature for Aphebian and other rock units, southern Labrador Trough, Grenville Province. Canadian Journal of Earth Sciences, Volume 17, pages 668-70

1980c: Geological mapping in the Wabush - Labrador City area, southwestern Labrador. *In* Current Research. *Edited by* C. F. O'Driscoll and R. V. Gibbons, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 206-212.

1980d: Sawbill Lake, 23G/7; Newfoundland Department of Mines and Energy, Mineral Development Division, Map 80-2, with marginal notes.

Rivers, T., and Massey, N.
1979: Wabush Lake - Sawbill Lake map area, western Labrador. *In* Report of Activities for 1978. *Edited by* R. V. Gibbons, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 79-1. pages 142-147.

Streckeisen, A.
1976: To each plutonic rock its proper name. Earth Science Reviews, Volume 212, pages 1-33.

Tiphane, M.
1951: Geology of south Menihek Lake area; 1 inch to 1/2 mile. Iron Ore Company of Canada, map and report.

Wall, R.M.
1953: Geological report for Sea Horse Lake area; 1 inch to 1/2 mile. Newfoundland and Labrador Corporation, map and report.

Wynne, Edwards, H. R.
1972: The Grenville Province. *In* Variations in Tectonic Styles in Canada. *Edited by* R. A. Price and R. J. W. Douglas. Geological Association of Canada, special paper, number 11, pages 263-334.

GEOLOGY OF THE NOTAKWANON RIVER AREA, LABRADOR

by

J.D. Hill and R.S. Epstein[1]

INTRODUCTION

This report gives the preliminary results of the fourth year of a regional bedrock mapping project in the Davis Inlet - Mistastin Lake corridor. The area mapped in 1980 comprises four 1:50,000 scale N.T.S. map sheets (13M/9, 13M/10, 13M/15, 13M/16). It is bordered on the east by the Flowers River area (Hill, in preparation) and on the west by the Mistastin Lake area, currently being mapped by R.F. Emslie of the Geological Survey of Canada.

The eastern part is mainly underlain by undeformed igneous intrusive rocks and is marked by numerous rugged hills rising 300 to 500 m above the river valleys and lakes. Bedrock exposure is good and mapping was done by ground traverses supported by helicopter. To the west, the land is underlain by gneisses of the Churchill Structural Province and is characterized by low, rounded hills and extensive plains covered with glacial drift and sand. Bedrock exposure is sporadic and mapping was done mainly by helicopter along east-west flight lines spaced at 1.5 km intervals.

Previous geological work is limited to reconnaissance mapping by Brinex (Beavan, 1954) and the Geological Survey of Canada (Taylor, 1972, 1979). The map given here incorporates work done between 1977 and 1980 as well as the field data of Taylor (1972). Two areas remain unmapped because of inclement weather in the summer of 1980.

REGIONAL GEOLOGICAL SETTING

The area straddles the southwest margin of the Nain Igneous Complex with the Churchill Structural Province. The western and southern parts are underlain by a variety of supracrustal and plutonic gneisses which are believed to be Aphebian in age or older. They were deformed and metamorphosed during the Hudsonian Orogeny about 1700 Ma (Emslie, 1978). The amount of deformation within the gneisses is variable and sedimentary bedding and igneous plutonic textures can be recognized in places. Dikes and lenses of slightly deformed to undeformed leucogranite pegmatite and undeformed diabase dikes have intruded the gneisses locally.

The Nain Igneous Complex is a bimodal suite of granitic and anorthositic intrusions of Paleohelikian age. These rocks are undeformed except for isolated shear zones and were emplaced in an anorogenic environment. Numerous screens of Churchill gneiss are preserved between some of the plutons in the igneous complex.

DESCRIPTION OF UNITS

Churchill Structural Province

Unit 1: Amphibolite

Amphibolite occurs in several north to northwest trending belts up to 1 km thick. It is also present as thin layers in banded gneiss in Unit 2, and as blocks and bands in migmatite south of the 452 m lake.

The amphibolite consists mainly of plagioclase and amphibole with accessory amounts of clinopyroxene, epidote and opaques. Quartz is also present in some samples in trace amounts. Garnet has been reported in amphibolite farther north (Taylor, 1979) but was not identified in the current map area. The proportions of plagioclase and amphibole

1. University of Western Ontario, London, Ontario.

are variable and individual bands and outcrops may contain up to 100% amphibole.

The texture is typically fine to medium grained and schistose to finely banded. The banding tends to be streaky and discontinuous and is defined by alternations of plagioclase and mafic-rich lithologies. In places, the white-weathering feldspathic streaks also contain a few percent quartz. In some outcrops, the amphibolite is coarse grained and takes on a blotchy or tiger-stripe appearance, depending on the amount of strain present. Coarse grained to pegmatitic plagioclase-amphibole stringers trend parallel to the foliation in places and emphasize the fabric where they are present. Most of the occurrences of Unit 1 contain variable amounts of mylonitic to gneissic leucogranite (Unit 5). The leucogranite intrudes the amphibolite and the two lithologies form injection and banded migmatite where the proportion of leucogranite is large.

No primary structures were found preserved in the amphibolite. This feature led Taylor (1979) to suggest the unit may have been formed by the intrusion of gabbro sills. However, in 13M/15 and in 13N/12 (Hill, 1980), amphibolite is interlayered with felsic gneisses of highly uniform texture and composition and the rocks resemble a volcanic sequence.

Unit 2: Diorite to Tonalite Gneiss

A large variety of dioritic to tonalitic gneisses is included in Unit 2. At least four types can be recognized. These are diorite to quartz diorite gneiss, well banded tonalite gneiss, unbanded and mylonitic to streaky tonalite gneiss, and obvious paragneiss. These lithologies are commonly mixed together in alternating outcrops and are only locally subdivisible at map scale.

The diorite to quartz diorite gneiss is the dominant lithology in Unit 2 along the western boundary of the map area and is also present as bands and whole outcrops in Unit 2 farther east. It is fine to medium grained and finely banded to streaky. In a few outcrops, it is interbanded with amphibolite and tonalite gneiss and, in one place, contains blocks of amphibolite. Quartz generally varies between 0% and 15%. The mafic minerals are typically amphibole and biotite and amount to 20% to 35% of the rock.

Well banded tonalite gneiss underlies large parts of the central and southern areas included in Unit 2. It is typically medium grained and individual bands vary from 1 mm to 1 m thick. The bands range from amphibolite to granite in composition but tonalite is the most common type. The mafic minerals range from 5% to 20% on average and include biotite, amphibole, clinopyroxene, orthopyroxene and garnet. Quartz varies between 15% and 30% except in the most mafic bands, where it may be absent. Sillimanite was identified in only a few outcrops. Two outcrops of banded tonalite gneiss were observed which contain isolated inclusions of amphibolite similar to that in Unit 1.

The unbanded to streaky tonalite gneiss is mainly restricted to the northeast part of the Churchill gneiss terrain in 13M/15. It is fairly homogeneous in composition and texture except for scattered layers of amphibolite up to a few metres thick. The banding, where present, is defined by discontinuous streaks of slightly varying composition up to a few millimetres thick. In general, it is biotite tonalite in composition but locally appears to grade into granodiorite. Orthopyroxene was found in one sample. Microcline varies from 0% to 15%, quartz is 20% to 25%, and the mafic minerals are generally less than 12% of the rock.

LEGEND

PALEOHELIKIAN

Nain Igneous Complex

7 — *Medium to coarse grained equigranular granite, quartz monzonite, fine grained aphyric granite, quartz-feldspar porphyry;* 7a, *medium grained monzonite, monzodiorite, diorite.*

6 — *Coarse grained anorthosite and leucogabbro, minor fine grained olivine gabbro.*

APHEBIAN (OR OLDER)

Churchill Structural Province

5 — 5a, *Medium to coarse grained biotite metagranite with feldspar augen;* 5b, *Mylonitic, fine to medium grained biotite metagranite and metagranodiorite, locally gneissic.*

4 — 4a, *Coarse grained, megacrystic biotite-garnet metagranite to metatonalite;* 4b, *Mylonitic, fine to coarse grained biotite-garnet metagranite.*

3 — *Medium to coarse grained meta-anorthosite.*

2 — *Banded and mylonitic unbanded diorite, quartz diorite and tonalite gneiss, locally containing bands of granodiorite and granite gneiss.*

1 — *Fine to medium grained amphibolite.*

Migmatite consisting of mixed layers of units 1, 2, and 5.

SYMBOLS

Geologic boundary . . . . .

Plagioclase lamination (dip $> 30^{o}$, dip $< 30^{o}$) . . . . .

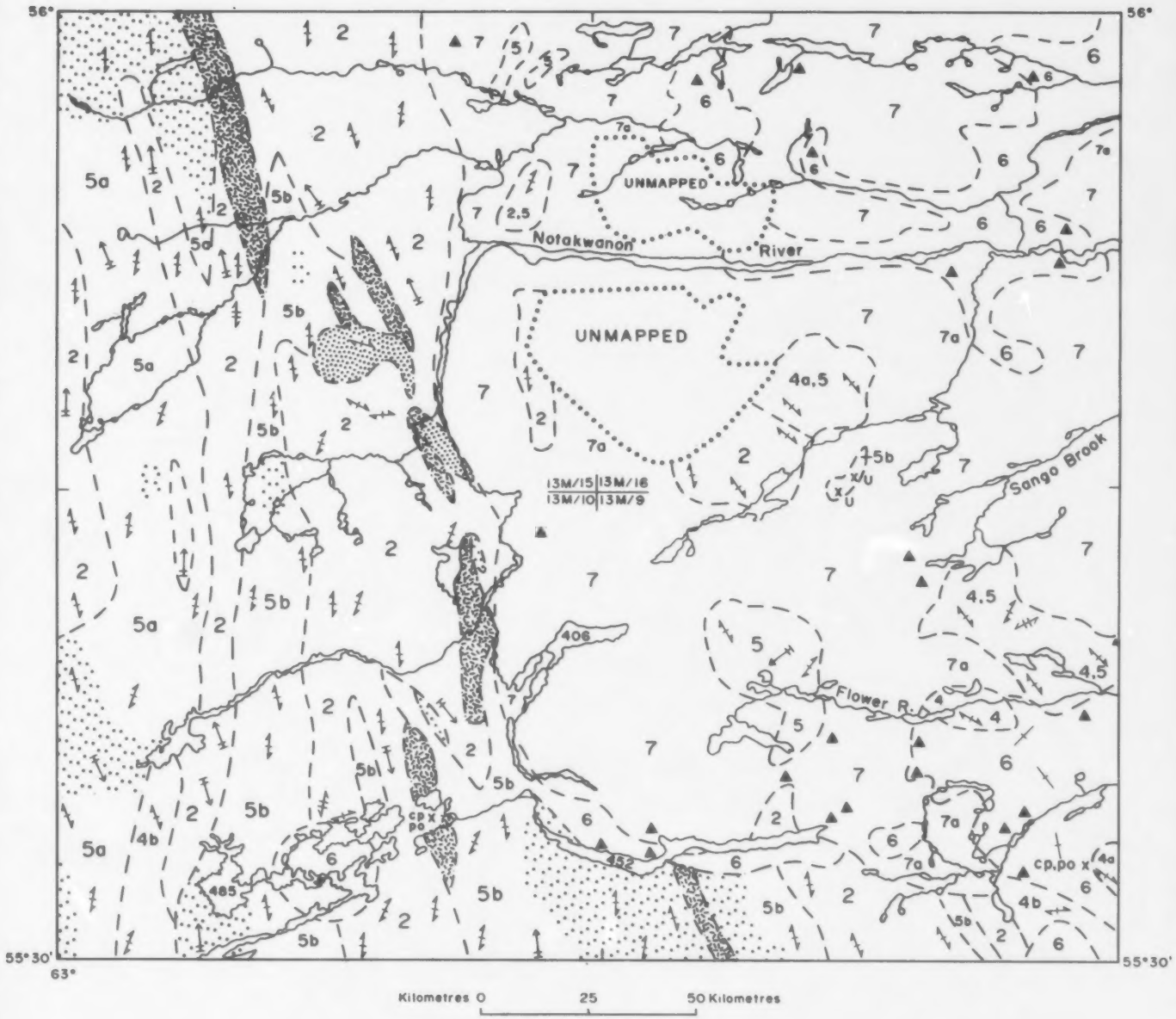
S_1 gneissic banding, shistosity (dip $> 30^{o}$, dip $< 30^{o}$) . . . . .

S_2 mylonitic foliation (dip $> 30^{o}$, dip $< 30^{o}$) . . . . .

F_2 fold axis, L_2 mineral lineation (plunge $< 30^{o}$, plunge $> 30^{o}$) . . . . .

Agmatite . . . . . ▲

Mineral occurrence (po - pyrrhotite; cp - chalcopyrite; U - uranium) . . . . . ×


56°
56°
UNMAPPED
Notakwanon River
UNMAPPED
Sango Brook
Flower R.
13M/15 13M/16
13M/10 13M/9
406
452
485
cp,po x
55°30'
63°
55°30'
Kilometres 0 25 50 Kilometres

Obvious paragneiss occurs as isolated outcrops which could not be distinguished as a separate unit at map scale. These generally consist of banded tonalite to granodiorite gneiss and schist containing biotite, garnet and sillimanite. They are marked by bands enriched in graphite, pyrite or quartz. In addition, discontinuous lenses of marble were found in one outcrop of paraschist. The paragneiss and paraschist tend to be fine grained and compositionally layered. In places, the layering resembles relict bedding. All gradations between obvious paragneiss and the banded tonalite gneiss of uncertain origin described above were observed in the field.

All of the lithologies in Unit 2 are interbanded and crosscut by stringers of deformed and undeformed leucogranite. The deformed leucogranite resembles the rocks of Unit 5. The presence of inclusions of amphibolite in some outcrops of more homogeneous diorite to tonalite gneiss suggests that parts of Unit 2 may be intrusive in origin. The unbanded to streaky tonalite gneiss in 13M/15 is monotonous in texture and composition and is interlayered with amphibolite, suggesting that it may be volcanic in origin. At least some outcrops of the well banded tonalite gneiss must be sedimentary in origin since gradations with obvious paragneiss were recognized in the field.

Unit 3: Meta-anorthosite

Meta-anorthosite forms three small, elongate masses and one larger, more rounded body in 13M/15 and 13M/16. It is typically medium to coarse grained, white weathering and granoblastic. The mafic minerals are concentrated in streaks and layers up to 50 cm thick and the layers are commonly arranged in groups. Plagioclase ranges between 75% and 100% of the rock. The mafic minerals are mainly amphibole and biotite.

No contacts between Unit 3 and any other unit have been observed so its exact age is uncertain. However, the meta-anorthosite is folded and metamorphosed and must have been emplaced before the end of the Hudsonian Orogeny. The largest body appears to transect the stratigraphy of some of the gneisses to the north, suggesting that Unit 3 is younger than Units 1 and 2. Taylor (1979) has described similar meta-anorthosite which occurs farther north and which is crosscut by pegmatite dikes dated at 1530 Ma (K/Ar, biotite).

The mafic banding and overall composition of the meta-anorthosite suggest that it is intrusive in origin. Although meta-anorthosites of sedimentary origin have been recognized elsewhere (Hietanen, 1963), the aluminosilicate minerals characteristic of those bodies are lacking in Unit 3.

Unit 4: Biotite-garnet metatonalite to metagranite

Unit 4 forms only a small portion of the gneiss terrain in the current map area although it is more abundant farther east in 13N/12 (Hill, 1980). It is divided into a coarse grained, megacrystic phase (Unit 4a) and a finer grained, nonmegacrystic phase (Unit 4b). These rocks are similar in overall texture and composition to Unit 5 except that the latter lacks garnet.

The coarse grained phase (Unit 4a) is characterized by rounded megacrysts of quartz and feldspar up to 7 cm long. The megacrysts are aligned parallel to the foliation defined by a fine to medium grained schistose matrix. Where megacrysts are lacking, the rock tends to be more granoblastic and medium to coarse grained. The overall composition is tonalite to granite. Biotite and garnet are the dominant mafic minerals and amount to 5% to 20% of the rock. In addition, orthopyroxene was found in one specimen collected in the southeast corner of the map area.

The finer grained phase (Unit 4b) is white weathering and tends to have a mylonitic foliation. It locally contains crosscutting lenses and dikes of slightly deformed and undeformed biotite-garnet leucogranite pegmatite.

Unit 4b appears to be uniformly biotite-garnet granite in composition and mafic minerals tend to be less 10% of the rock.

The rocks of Unit 4 are uniform over large areas and gneissic banding tends to be lacking. However, changes in grain size, probably the result of strain variation, have produced a fine textural banding. In addition, inclusions and layers of Unit 2 are locally present in Unit 4 and give a banded appearance to the outcrop. The uniformity and granitoid textures of Unit 4 suggest it is intrusive in origin. The presence of inclusions of tonalite gneiss indicate it is younger than Unit 2. The relationship between Units 4a and 4b is uncertain. They may represent different ages of igneous activity or they may simply reflect textural variations in a single lithologic unit.

Unit 5: Biotite metagranodiorite, metagranite.

Leucocratic to mesocratic biotite metagranodiorite to metagranite forms a large part of the Churchill gneiss terrain. It is subdivided into a coarse grained, megacrystic phase (Unit 5a) and a fine to medium grained, mylonitic phase (Unit 5b). The two textural phases are separated at map scale but in places they coexist and may be gradational with each other.

The megacrystic phase (Unit 5a) is a foliate granite with augen of quartz and feldspar up to 10 cm long set in a fine to medium grained, schistose to granoblastic matrix of quartz, feldspar and minor biotite and amphibole. Quartz varies from 20% to 25% and the mafic minerals range from 5% to 15% of the rock. On average, the unit is texturally and compositionally uniform. In places, however, megacrysts are lacking and the rock is identical to Unit 5b. In some outcrops, the unit is faintly banded due to variations in texture and all gradations from fine grained, mylonitic granite to coarse grained, granoblastic and coarse grained, megacrystic granite may be present.

The mylonitic phase (Unit 5b) is typically homogeneous in composition and texture at outcrop scale. However, the rock is finely banded in places due to changes in grain size and the presence of lensoid, millimetre-thick compositional variations. In general, the unit is leucogranitic in composition but granodioritic and quartz monzonitic variations are present. Quartz ranges from 15% to 30%. The mafic minerals are mainly biotite and amphibole and range from 2% to 8% of the rock.

In places, Unit 5 contains bands and blocks of amphibolite and tonalite gneiss of Units 1 and 2. Where the proportions of mafic and felsic gneiss are approximately equal, the rocks are indicated as migmatite on the map (Figure 1). Typically, the migmatite is characterized by parallel bands of Units 1, 2 and 5 up to a few metres thick, but in some outcrops, the metagranite of Unit 5 crosscuts the mafic gneiss as dikes and injection migmatite is developed.

The relatively uniform composition and the local preservation of relict igneous plutonic textures in Unit 5 suggest it is intrusive in origin. The contrasting textures between Units 5a and 5b are believed to reflect, at least in part, predeformation differences modified by subsequent tectonism. However, in outcrops where the two textural phases are gradational and interbanded, the contrasting textures appear to reflect variations in tectonic strain. Dikes of Unit 5 crosscut rocks of Units 1 and 2. The contact relationships of Unit 5 with Units 3 and 4 were not observed.

Nain Igneous Complex

Unit 6: Gabbroid plutons

Several intrusions are exposed which contain undeformed rocks ranging from gabbro to anorthosite. In addition, isolated outcrops of anorthosite and leucogabbro are preserved within the granitoid rocks of Unit 7.

Plagioclase is the dominant mineral and typically ranges from 70% to 100% of the rock. It is generally close to An_{50} in composition but ranges to An_{69} in leucogabbro southeast of the 452 m lake. The plagioclase tends to occur as decussate to foliate subhedral laths which are unzoned. The main mafic minerals are olivine, clinopyroxene and opaques. However, olivine or clinopyroxene may be absent in some outcrops. Olivine occurs in two habits. The more common type is poikilitic and encloses plagioclase grains. However, in some outcrops, olivine occurs as equant subhedra lying between the plagioclase laths. Clinopyroxene is typically poikilitic and the opaques generally form wedge-shaped grains bounded by plagioclase laths.

Gabbro was only found as fine grained rock at the margins of two of the plutons. On the south shore of the 452 m lake, the gabbro is fine grained and massive and is in concordant contact with tonalite gneiss. The gabbro gradually becomes coarser grained and more leucocratic east of the contact and, 40 m from the contact, the rock is coarse grained leucogabbro with about 30% mafic minerals. On the north side of the lake, the contact relationships are obscured by lichen cover. However, medium grained leucogabbro occurs to within 1 m of the gneiss contact and no gabbro was recognized. In the southeast corner of the map area, another contact between gneiss and Unit 6 is exposed. Here, the gabbro is fine grained, highly altered and contains 1% plagioclase phenocrysts and numerous xenoliths of gneiss.

The gabbro-anorthosite plutons are correlated with similar intrusions farther east and north in the Nain Igneous Complex. Textures and structures in the Flowers River area indicate the plutons are cumulate in origin (Hill, in preparation) and a similar origin is interpreted for the Notakwanon River area.

The shapes of most of the plutons are unknown. The large gabbroid pluton in the northeast part of 13M/16 is only exposed in river valleys whereas Unit 7 is exposed on the surrounding hill tops. This suggests the contact between the gabbroid and granitoid rocks in that area is approximately horizontal. The relative age of the gabbroid plutons is indicated by the presence of monzonite and granite dikes of Unit 7 which cut leucogabbro and anorthosite in several places. One gabbroid pluton differs from the others in that it is highly altered and for this reason may be older than the gabbroid plutons of the Nain Igneous Complex. The pluton is poorly defined because of lack of outcrop and lies within the gneiss terrain east of the 452 m lake.

Unit 7: Granitoid plutons

Unit 7 includes a large variety of undeformed intrusive rocks which range from diorite to granite in composition. An older group consists of quartz-poor lithologies and includes diorite, monzodiorite and monzonite. The younger group includes granite, granodiorite, quartz monzonite and their fine grained and porphyritic equivalents. The two groups are locally difficult to distinguish in the field and have been mapped as a single unit until thin section data become available.

The quartz-poor granitoid rocks (Unit 7a) form several small plutons which lie between the gabbroid intrusions of Unit 6 and the granite of Unit 7. They range from diorite to monzonite due to variations in the proportions of potassium feldspar and plagioclase. Quartz is typically less than 10% and is absent in many outcrops. The dominant mafic minerals are amphibole, clinopyroxene and olivine but biotite and orthopyroxene are important constituents in some samples.

The quartz-rich granitoid rocks may be divided into two textural phases; namely, a suite of fine grained and

porphyritic rocks and a suite of medium to coarse grained, equigranular rocks. Both phases are similar in composition and granite is the most abundant type. Quartz is generally 20% to 35% except in places north of the Notakwanon River in 13M/16, where quartz monzonite with only 10% to 15% quartz occurs. The relationship of the quartz monzonite with the more common granite is uncertain. The proportions of plagioclase and potassium feldspar are variable and the granite locally grades into granodiorite. The main mafic minerals are olivine, amphibole and clinopyroxene although biotite is present in some samples. The fine grained phase includes an aphyric variety and quartz-feldspar porphyry. These rocks are widely distributed throughout Unit 7 and occur exclusively associated with the amphibole-clinopyroxene-olivine granite and granodiorite (Figure 2). The fine grained phase is present as blocks and larger, undefined zones in the granite. The contacts between the two phases are typically intrusive and dikes of granite cut the fine grained phase in many places. However, at two localities, the fine grained phase grades into the coarse grained, equigranular granite over a few millimetres.

The low quartz plutons ranging from diorite to monzonite form an older group distinct from the quartz-rich granitoid rocks. Dikes of granite cut monzonite and diorite in several places. These rocks form a volumetrically minor suite of plutons intermediate in age and composition between the gabbroid and quartz-rich granitoid intrusions in the Nain Igneous Complex. The granite and related rocks represent the last period of intrusive activity in this part of the Nain Igneous Complex. The widespread association, similar composition, and local gradational contacts of the fine grained and coarse grained phases suggest the two varieties are genetically related. The fine grained phase may represent a foundered roof broken up and engulfed by the main body of rising granite magma. This idea is not supported by a Rb/Sr whole rock isochron for the granite in Unit 7. Two samples of quartz-feldspar porphyry fall off the line defined by six samples of coarse grained granite (Brooks, personal communication). The six granite samples give an age of 1217 $\pm$ 24 Ma with an initial ratio of 0.7101 $\pm$ 0.0009.

Diabase Dikes

Small, undeformed diabase dikes intrude both the Churchill gneisses and the Nain Igneous Complex. Several dikes up to a few metres thick were found in the gneisses oriented parallel to the gneissosity in the host rock. The diabase is fine to medium grained and hydrothermally altered, although primary plagioclase and clinopyroxene can still be recognized in thin section. Two diabase dikes, one unaltered and the other partly altered, were found crosscutting granite of Unit 7 in the Nain Igneous Complex. Both contain significant amounts of olivine in addition to plagioclase, clinopyroxene and opaques.

STRUCTURE AND METAMORPHISM

The Churchill gneisses and the intrusive rocks of the Nain Igneous Complex are separated in time and structure by the Hudsonian Orogeny which occurred about 1700 Ma (Emslie, 1978). This was the last period of penetrative deformation in the area and the intrusions of the Nain Igneous Complex appear to have been emplaced in an anorogenic environment.

Two phases of penetrative deformation have been recognized in the gneisses and are attributed to the Hudsonian Orogeny. The earliest phase (D_1) is represented by gneissic banding (S_1) which is best developed in Unit 2 and is sporadically developed in Units 1, 4 and 5. The banding in the meta-anorthosite of Unit 3 appears to be relict igneous layering which may or may not have been modified by D_1.

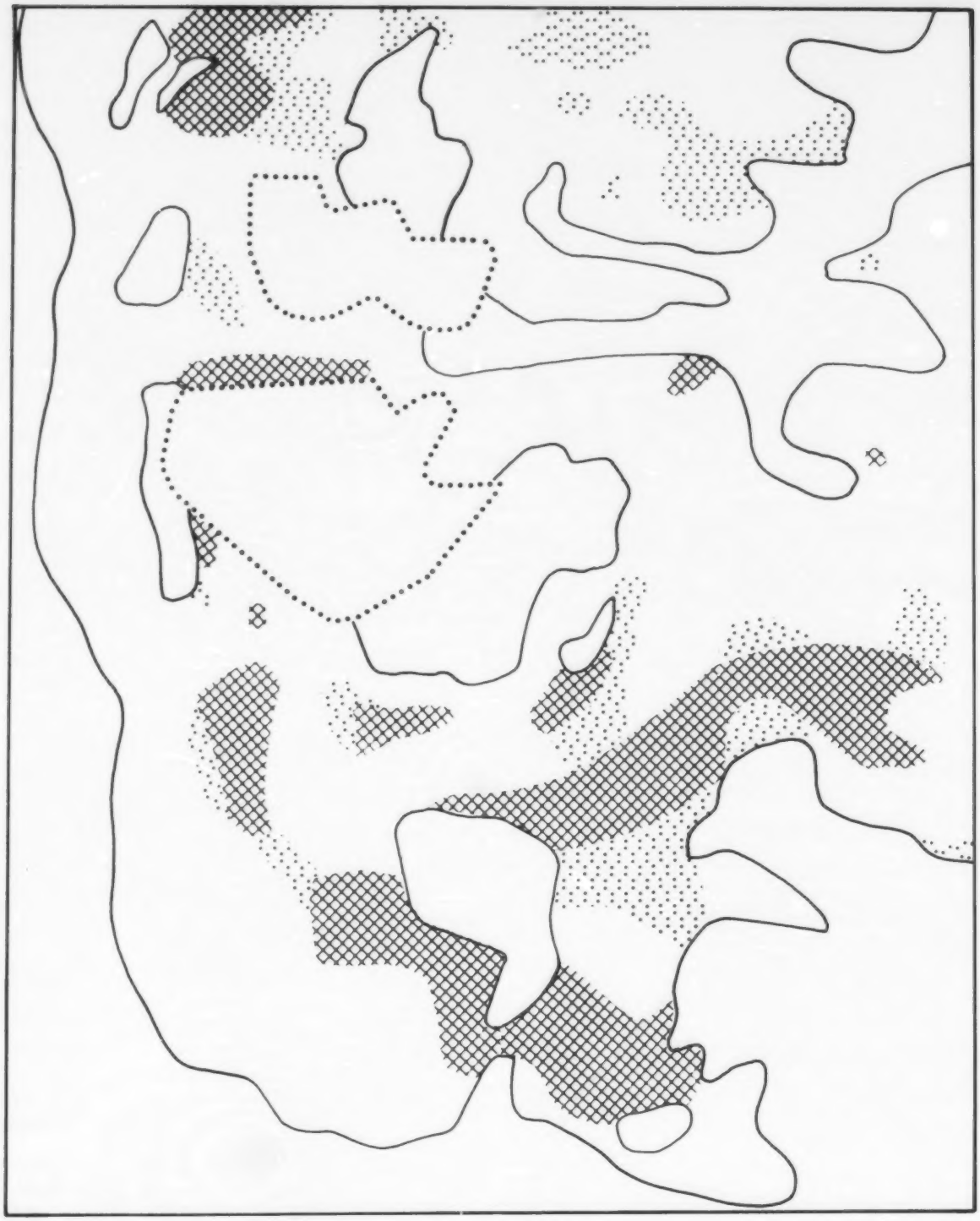


Figure 2 - Distribution of fine grained granite and quartz - feldspar porphyry in Unit 7.

F3

Amphibolite grade metamorphic mineral assemblages are typically associated with S_1 as shown by the widespread occurrence of biotite, amphibole and clinopyroxene. Sillimanite is present in some parts of Unit 2. Garnet is common in Units 2 and 4 but it appears to have formed prior to S_1. Orthopyroxene is associated with S_1 in scattered outcrops of Unit 2 and may indicate regional granulite grade metamorphism during D_1.

A second phase of deformation (D_2) is shown by a mylonitic foliation (S_2) which is invariably oriented parallel to S_1 except at F_2 fold closures. The formation of S_2 appears to have been mainly cataclastic and ribbon quartz, mortar structure, granulation and broken grains are developed. However, in places, metamorphism appears to have been sufficient for the recrystallization of fine grained quartz, feldspar and biotite. Many outcrops are texturally banded on a centimetre to decimetre scale due to variations in grain size and degree of perfection of the mylonitic fabric. This appears to have been caused by variations in strain across strike during D_2. Mesoscopic folds (F_2) with subhorizontal plunges and upright axial planes are associated with S_2. A mineral lineation (L_2) with a subhorizontal plunge is also present and in some outcrops it is the dominant penetrative fabric preserved. Where L_2 is well developed and inclusions of more mafic material occur, the inclusions are rod shaped and are oriented parallel to the mineral lineation.

A third period of regional deformation may have affected the Churchill gneisses. S_1, S_2 and F_2 structures are deflected into a large S-sense flexure centered on a meta-anorthosite body northwest of the 406 m lake in 13M/15. An outcrop of granite gneiss immediately north of the meta-anorthosite has S-sense mesoscopic folds which plunge 40° at 340° while S_1 and F_2 in the same outcrop trend at 315°.

Isolated shear zones occur within single outcrops in both the gneisses and the Nain Igneous Complex. Zones of mylonite up to a few centimetres thick are developed in some of the shears. In the eastern part of the map area, the shears are oriented east-west and the movement was sinistral. They crosscut the Nain Igneous Complex as well as older gneisses farther east (Hill, in preparation). In the gneiss terrain in the western part of the area, the shears are oriented east-west to northeast-southwest and movement was dextral. These shears have not been recognized in any rocks younger than the Churchill gneisses.

The Nain Igneous Complex is marked by numerous major topographic lineaments. Significant fault movement along these lineaments has not been recognized in the map area. However, outcrops in the valleys of some of the lineaments are marked by fractures, hydrothermal alteration and quartz veins. In addition, brecciation was found in fracture planes in one outcrop.

ECONOMIC GEOLOGY

Mineral showings are present in both the Churchill gneisses and the Nain Igneous Complex. The most significant showing consists of uranium mineralization in a screen of leucocratic metagranite surrounded by Unit 7 northeast of the 406 m lake. It was located by detailed examination of the area around a lake sediment geochemistry anomaly (McConnell, 1981). The mineralization is associated mainly with fractures in the metagranite and is widespread throughout the screen. Similar muscovite-biotite metagranite is present in screens northwest and southeast of the uranium showing and may contain additional mineral occurrences. A more detailed description of the uranium showing is given by McConnell in this report.

Taylor (personal communication) found disseminated chalcopyrite, pyrite and pyrrhotite in amphibolite dikes which crosscut metadiorite (Unit 1) west of the 452 m lake. Disseminated pyrite, pyrite veinlets and gossan are widely distributed in amphibolite south of the 452 m lake and in paragneiss and amphibolite in 13M/15.

The only mineral showing found in rocks of the Nain Igneous Complex consists of disseminated chalcopyrite, pyrrhotite and pyrite in coarse grained anorthosite situated in a stream bed east of the 452 m lake. The mineralization is very localized and consists of less than 1% total sulfides.

ACKNOWLEDGEMENTS

The writers were ably assisted in the field by B.M. Murrin, J.M. Hill and D.F. Starr. The Rb/Sr geochronology was completed under the direction of C. Brooks at the Universite de Montreal. Additional field data have been supplied by F.C. Taylor of the Geological Survey of Canada and J. McConnell of the Newfoundland Department of Mines and Energy.

REFERENCES

Beavan, A.P.
1954: Report on exploration in Labrador and Newfoundland, 1953. British Newfoundland Corp. Ltd.

Emslie, R.F.
1978: Elsonian magmatism in Labrador: age, characteristics and tectonic setting. Canadian Journal of Earth Science, volume 15, pages 438-453.

Hietanen, A.
1963: Anorthosite and associated rocks in the Boehls Butte Quadrangle and vicinity, Idaho. United States Geological Survey, Professional Paper 344B.

Hill, J.D.,
1980: Continued geologic mapping in the Davis Inlet - Mistastin Lake corridor, Labrador. *In* Current Research, Newfoundland Department of Mines and Energy, Report 80-1, pages 222-229.

1981: Geology of the Flowers River area, Labrador. Preliminary report, Newfoundland Department of Mines and Energy, in preparation.

McConnell, J.W.
1981: Stream and soil geochemical surveys in Labrador. Newfoundland Department of Mines and Energy, Mineral Development Division, this volume.

Taylor, F.C.
1972: Reconnaissance geology of a part of the Precambrian Shield, northeastern Quebec and northern Labrador; part III. Geological Survey of Canada, Paper 71-48.

1979: Reconnaissance geology of a part of the Precambrian Shield, northeastern Quebec, northern Labrador and Northwest Territories. Geological Survey of Canada, Memoir 393.

LABRADOR GEOCHRONOLOGY

compiled by

R.J. Wardle

Recent Radiometric Age Determinations

Rock Unit or Mineralization	Method and Geochronologist	Date (Ma)	Interpretation
Central Labrador Trough			
Shabogamo Intrusive Suite gabbro-McLean Outlier (Unit 12, Ware & Wardle, 1979)	Ar^{40}/Ar^{39} biotite (D. Dallmeyer)	1352±18	Age agrees well with Sm-Nd determination - see below - no effects seen of Grenvillian thermal overprinting.
"	Sm - Nd (C. Brooks)	1390	Supersedes previous erroneous Rb-Sr determination of 1685 Ma (see Current Research 80-1)
Southern Labrador Trough	Ar^{40}/Ar^{39} w.r. (D. Dallmeyer)		
Phyllites from Menihek Fm., Knob Lake Group (Unit 9, Rivers, 1980)	"	873±15	Phyllites collected from low grade metamorphic zone along western margin of Trough. Metamorphism is entirely of Grenvillian age with no evidence of a Hudsonian disturbance.
"	"	1006±20	
"	"	936±18	
Red Wine Mountains area, central Grenville Province			
Letitia Lake Porphyry (Thomas, 1981)	Rb-Sr w.r. isochron (B. Fryer)	1067±86	Grenvillian metamorphic age on quartz-feldspar porphyry from upper Letitia Lake Group.
Wapustan Gneiss (Thomas, 1981)	"	1660±37	Hudsonian gneiss, age of which has been reset by thermal metamorphism associated with intrusion of granitoids belonging to North Pole Brook Intrusive Suite.

Red Wine biotite-hornblende granodiorite - quartz monzonite (Unit 7a, Thomas, 1981)	Rb-Sr w.r. isochron (B. Fryer)	1667±38	Late Hudsonian postkinematic granodiorite belonging to North Pole Brook Intrusive Suite, cooling age.
Red Wine leucogranodiorite (Unit 7a, Thomas, 1981)	"	1638±13	More differentiated equivalent of above unit, also part of North Pole Brook Intrusive Suite, cooling age.
Red Wine granodiorites combined (Unit 7a, Thomas, 1981)	"	1657±26	
Megacrystic granodiorite - quartz monzonite (Unit 7a, Thomas, 1981)	"	1703±176	Late Husonian, postkinematic granodiorite, belonging to North Pole Brook Intrusive Suite, cooling age.
Combined granodiorites - quartz monzonites (Unit 7a, Thomas, 1981)	"	1654±22	Age of intrusion of North Pole Brook Intrusive Suite as a whole.
Equigranular granodiorite - quartz monzonite (Unit 7a, Thomas, 1981)	"	1503±93	Late Hudsonian postkinematic granodiorite belonging to North Pole Brook Intrusive Suite, cooling age.

References

Thomas, A.
1981: Geology along the southwestern margin of the Central Mineral Belt. Newfoundland Department of Mines and Energy, Mineral Development Division, preliminary report, in press.

Rivers, T.
1980: Sawbill Lake, Newfoundland-Quebec. Newfoundland Department of Mines and Energy, Mineral Development Division, preliminary map 80-2.

Ware, M.G. and Wardle, R.J.
1979: Geology of the Sims-Evening Lake area with emphasis on the Helikian Sims Group. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 79-5.

RECONNAISSANCE GEOCHEMICAL LAKE SEDIMENT PROGRAM, TERRA NOVA AREA, NORTHEAST NEWFOUNDLAND

by

A.J. Butler

INTRODUCTION

The reconnaissance lake sediment program for 1980 was conducted in northeastern Newfoundland (Figure 1). An area of approximately 17,000 km^2 was surveyed east of a line running from the coast south along longitude 56°W to latitude 49°N, east to longitude 55°30'W, south to latitude 48°15'N, then east to the coast. The area surveyed adjoins the 1977 survey (Meelpaeg Lake area, Open File Nfld. 986) along part of the western boundary and the 1978 survey (Fortune-Trinity Bay area, Open File Nfld. 1002) to the south. There were 2,450 sites sampled and 2593 samples collected (including replicate samples) for a sampling density of one per 6.9 km^2. The sampling and analytical methods are described elsewhere (Butler, 1980).

GEOLOGY

The area (Figure 2) can be divided into three sections. To the east are the Avalon Zone rocks, mainly Hadrynian in age and consisting of clastic and tuffaceous sedimentary rocks and acidic to mafic volcanic rocks underlain by siltstone, slate, graywacke, sandstone and argillite and overlain locally by quartzites of the Random Formation and Cambro-Ordovician sedimentary rocks. The central section consists of Gander Zone lithologies, generally consisting of Ordovician intermediate to mafic volcanic rocks, slate, graywacke, siltstone, chert, conglomerate and minor limestone and their metamorphosed equivalents. To the west is the Botwood Zone, consisting of Silurian volcanic and sedimentary rocks. The Botwood and Gander Zones and the western margin of the Avalon Zone have been intruded by granite and related rocks with minor mafic and ultramafic rocks of probable Devonian age.

MINERAL POTENTIAL

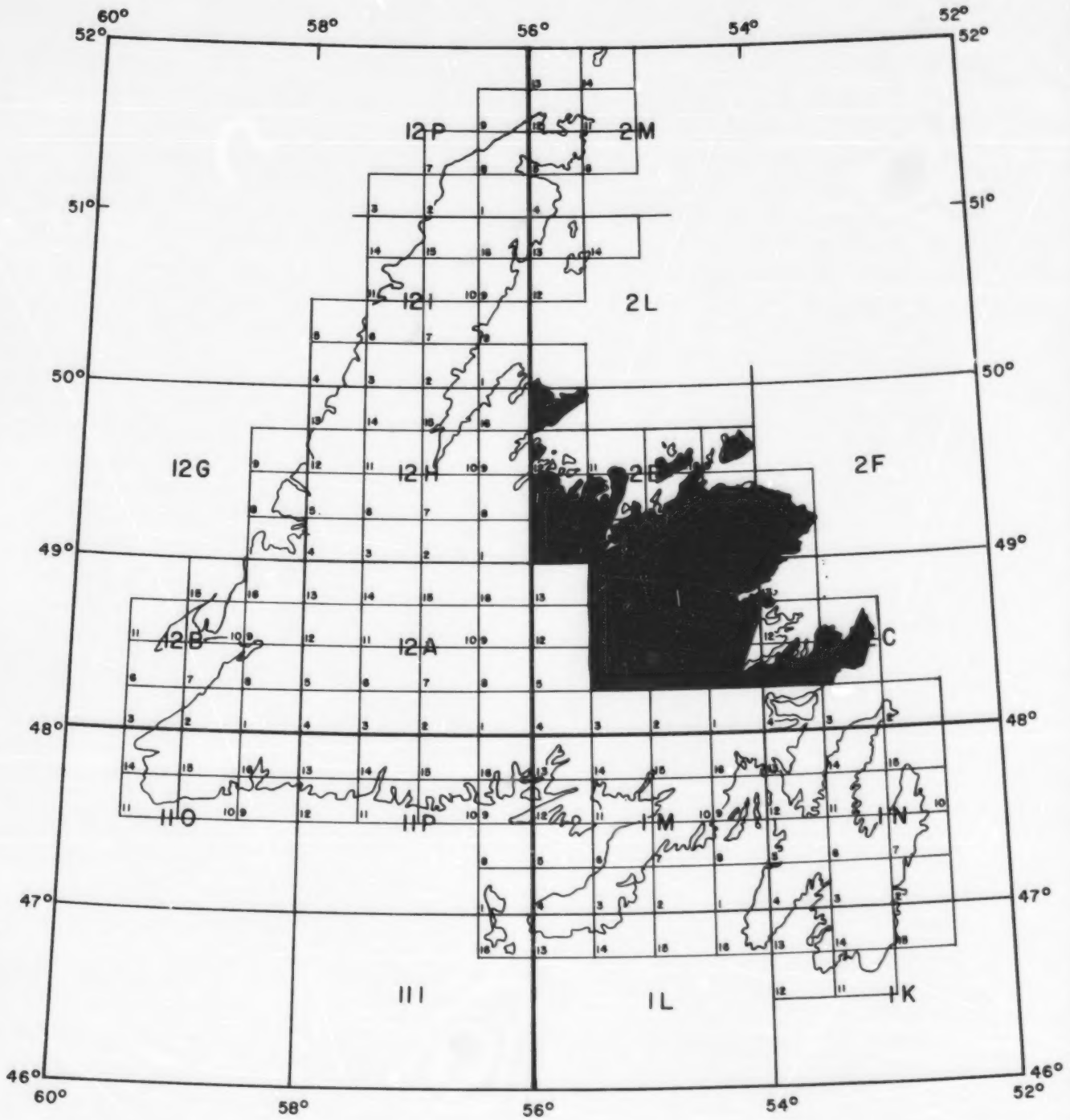
The abundance of base metal showings in the Notre Dame Bay area is well documented (Douglas, 1976); however, many of these showings are not extensive. Several base metal properties occur within the area, including Little Bay, Crescent Lake, Lockport, Miles Cove, Pelley's Island and Point Leamington (Dean, 1977). The base metal potential of the Gander Zone is less well known. A few copper showings are recorded around Kepenkeck Lake and minor showings occur on the coast near Doting Cove. The mineral potential of the Hadrynian rocks of the Avalon Zone is reviewed in detail in Taylor *et al.*, 1979.

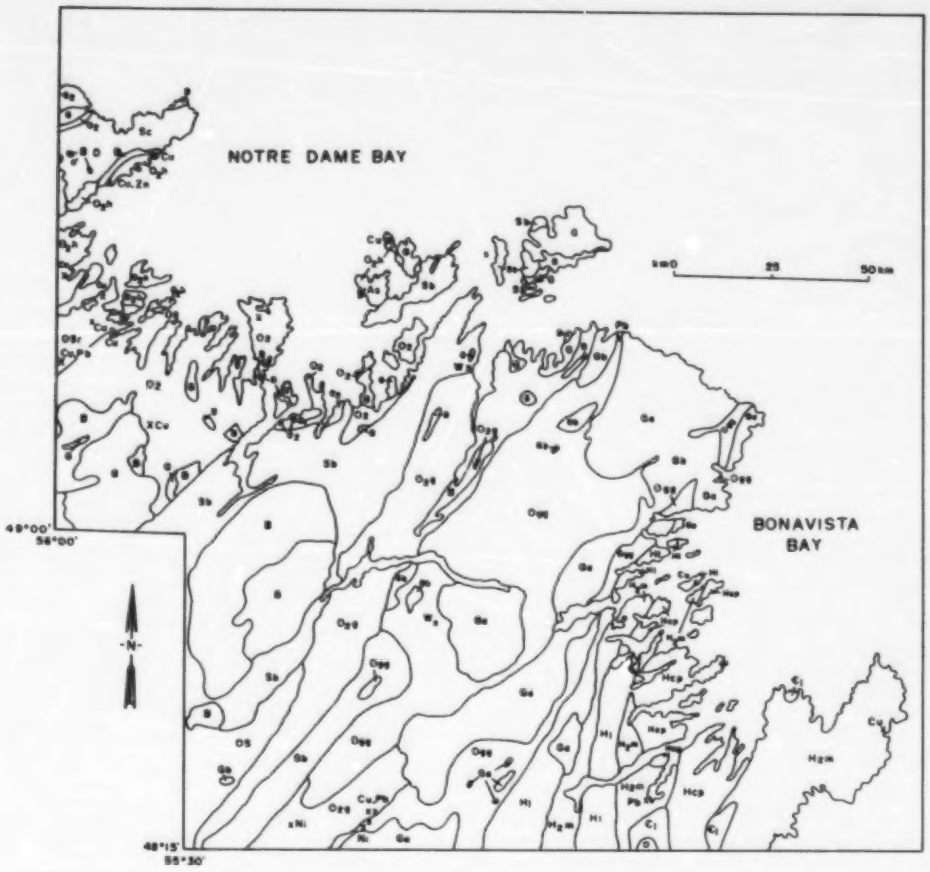
Minor showings of nickel are associated with the mafic rocks of the Gander Zone. Arsenic and antimony were once mined near Moreton's Harbour; gold and silver are also associated with this area. One tungsten prospect is located on the west side of Gander Bay and another south of Rodney Pond.

Knowledge of the mineral potential of the granitic intrusions is limited. Some molybdenum, beryllium, and fluorite showings are noted in the Wesleyville area.

OPEN FILE RELEASE

The data collected during this survey will be released on four sets of element distribution maps for each of Cu, Pb, Zn, Co, Ni, Ag, Mn, Fe, F, Mo, and U plus LOI and a set of sample location maps on a scale of 1:250,000 with a geological base. Included with this data will be reanalyzed samples collected in 1974 on the Burlington Peninsula, previously released as Open File Nfld. (785).


60°
58°
56°
54°
52°
52°
51°
50°
49°
48°
47°
46°
12P
2M
12I
2L
12G
12H
2E
2F
12B
12A
C
11O
11P
1M
1N
111
1L
1K



LEGEND

DEVONIAN

G *Granite, granodiorite syenite and related rocks;* Ga, *coarse grained porphyritic biotite granite;* Gb, *garnetiferous muscovite leucogranite*

B *Gabbro, diorite, pyroxenite, quartz diorite and related rocks*

SILURIAN

S *Sandstone, conglomerate, acidic to mafic volcanic rocks, graywacke, shale, limestone;* Sb, BOTWOOD GROUP; Sc, CAPE ST. JOHN GROUP

OS *Slate, graywacke, acidic to mafic volcanic rocks, quartzite, chert, limestone;* OSr, ROBERTS ARM GROUP

ORDOVICIAN

O_2 *Intermediate to mafic volcanic rocks, slate, graywacke, siltstone, chert, conglomerate, minor limestone, shale, siltstone, mudstone;* O_2g, GANDER LAKE GROUP; O_2h, HEADLANDS GROUP

O CLARENVILLE GROUP: *Shale, siltstone, sandstone*

Ogg *Granite gneiss*

CAMBRIAN

Shales with limestone, conglomerate, siltstone, sandstone; *includes* RANDOM FORMATION: *Quartzite, sandstone and conglomerate;* FLEUR DE LYS GROUP: *Psammitic to pelitic gneiss and schist, marble, chloritic green schist, amphibolite*

HADRYNIAN

Hm MUSGRAVETOWN GROUP: *Siltstone, arkose, conglomerate, slate, minor acid to intermediate volcanic rocks*

Hcp CONNECTING POINT GROUP: *Slate, siltstone, graywacke, conglomerate, minor volcanic rocks*

Hl LOVE COVE GROUP: *Acidic to mafic volcanic rocks with minor sedimentary rocks and metamorphic equivalents*

ACKNOWLEDGEMENTS

The funding of this project was provided under the Canada-Newfoundland Mineral Development Agreement. Versatile Air Services Limited, Sydney, Nova Scotia, provided helicopter support on a contractual basis. Field assistance was provided by Janet Russell and Andrew Driscoll, with a special appreciation to Chris Finch for his assistance early in the project.

REFERENCES

Butler, A.J.
1980: Lake sediment geology, Lloyd's River area, southwest Newfoundland. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 230-239.

Butler, A.J. and P.H. Davenport
1978: Lake sediment geochemical survey, Meelpaeg Lake area. Newfoundland Department of Mines and Energy, Mineral Development Division, Open File Nfld. (986).

1979: Lake sediment geochemical survey, Fortune-Trinity Bays area, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Open File Nfld. (1002).

Davenport, P.H. and Butler, A.J.
1975: Geochemical stream and lake sediment surveys of the eastern part of the Burlington Peninsula, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Open File Nfld. (785).

Dean, Paul L.
1977: A report on the geology and metallogeny of the Notre Dame Bay area to accompany metallogenic maps 12H/1, 8, 9 and 2E/3, 4, 5, 6, 7, 9, 10, 11 and 12. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 77-10.

Douglas, C.
1976: Mineral occurrence tables, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Open File Nfld. 888.

Taylor, S.W., O'Brien, S.J., and Swinden, H.S.
1979: Geology and mineral potential of the Avalon zone and granitoid rocks of eastern Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 79-3.

Williams, H.
1967: Geology, Island of Newfoundland. Geological Survey of Canada, Map 1231A.

STREAM AND SOIL GEOCHEMICAL SURVEYS IN LABRADOR

by

J.W. McConnell

Field work in the summer of 1980 was done on four base metal anomalies and one uranium anomaly (see figure). These areas were selected on the basis of results from the previous year's detailed lake sediment/water sampling project of 14 regionally anomalous areas (Labrador Open File 224, 1980), which were themselves initially identified from the results of a regional lake sediment geochemical survey (Labrador Open Files 133, 396 and 13N (1978)).

The purposes of this year's project were twofold, firstly, to determine whether the anomalies could be related to bedrock mineralization in an effort to promote the exploration and development of the Province's mineral resources and, secondly, to evaluate the effectiveness of various geochemical exploration methods in the Labrador environment.

BASE METAL ANOMALIES

Stream sediments and water from Anomalies 1, 3 and 4 in N.T.S. areas 23J/10, 15 and 16 were collected at 250 m intervals from drainage systems having anomalously high base metal contents in lake sediment and water samples. All three areas are in the Labrador Trough and are underlain by shales and slates of the Menihek and Attikamagen Formations, some of which have been intruded by sills and dikes of Wakuach gabbro.

Zinc was of principal interest but high concentrations of silver and lead were commonly found in association. Stream waters were analyzed in the field for their heavy metal content using a colorimetric technique, and these data were used to further define particularly anomalous areas for detailed soil and till sampling.

Work at Anomaly 8 (N.T.S. sheet 13N/11) included grid cutting and soil sampling a 1.4 km^2 area adjacent to and surrounding two ponds with very high zinc and lead contents in their sediments and very high zinc contents in their waters. A V.L.F. survey was also made over the grid. The area is underlain by Helikian felsic volcanic rocks.

Results of the work on the base metal anomalies will be released as an open file report during the winter or spring of 1981.

URANIUM ANOMALY

Two areas totalling about 30 km^2 were selected from Anomaly 12 (N.T.S. sheets 13M/9 and 16) for detailed stream sediment and water sampling because of their high uranium contents in lake sediments and waters. These two areas were both found to be centered around exposures of Aphebian foliated leucogranite which are separated by Helikian intrusions of massive granitic to anorthositic rocks.

Mineralization. In addition to stream sampling, some scintillometer prospecting and mapping was done during which several occurrences of uranium mineralization were located. All occurrences found were in the foliated leucogranite and most consist of small veins a few to several metres in length. Some mineralization is restricted to "hot spots" and shear zones within the granite. The uranium mineralization, particularly in the southern area, is found most commonly as narrow, sharply defined veins commonly parallel or subparallel to the foliation; in some instances, the veins distinctly crosscut the fabric. Vein lengths vary from less than a metre to greater than 20 m. In some cases, isolated "hot spots" rather

GEOLOGY

GRENVILLE PROVINCE

HADRYNIAN — Supracrustal arkosic sedimentary rocks of the Double Mer Formation

HELIKIAN AND APHEBIAN — Metamorphosed equivalents of the Seal and Bruce River Groups

HELIKIAN AND EARLIER — Metamorphic rocks, mainly quartzofeldspathic gneisses

CHURCHILL PROVINCE

HELIKIAN — Supracrustal sedimentary and volcanic rocks of the Seal Group

APHEBIAN — Sedimentary and volcanic rocks of the Labrador Trough

APHEBIAN AND EARLIER — Metamorphic rocks, mainly quartzofeldspathic gneisses and granites

NAIN PROVINCE

HELIKIAN AND APHEBIAN — Supracrustal sedimentary and volcanic rocks of the Moran Lake and Bruce River Groups

APHEBIAN — Metamorphosed sedimentary and volcanic rocks of the Aillik Group

ARCHEAN — Basement gneisses

SUPERIOR PROVINCE

ARCHEAN — Granulitic gneisses and felsic to mafic intrusives

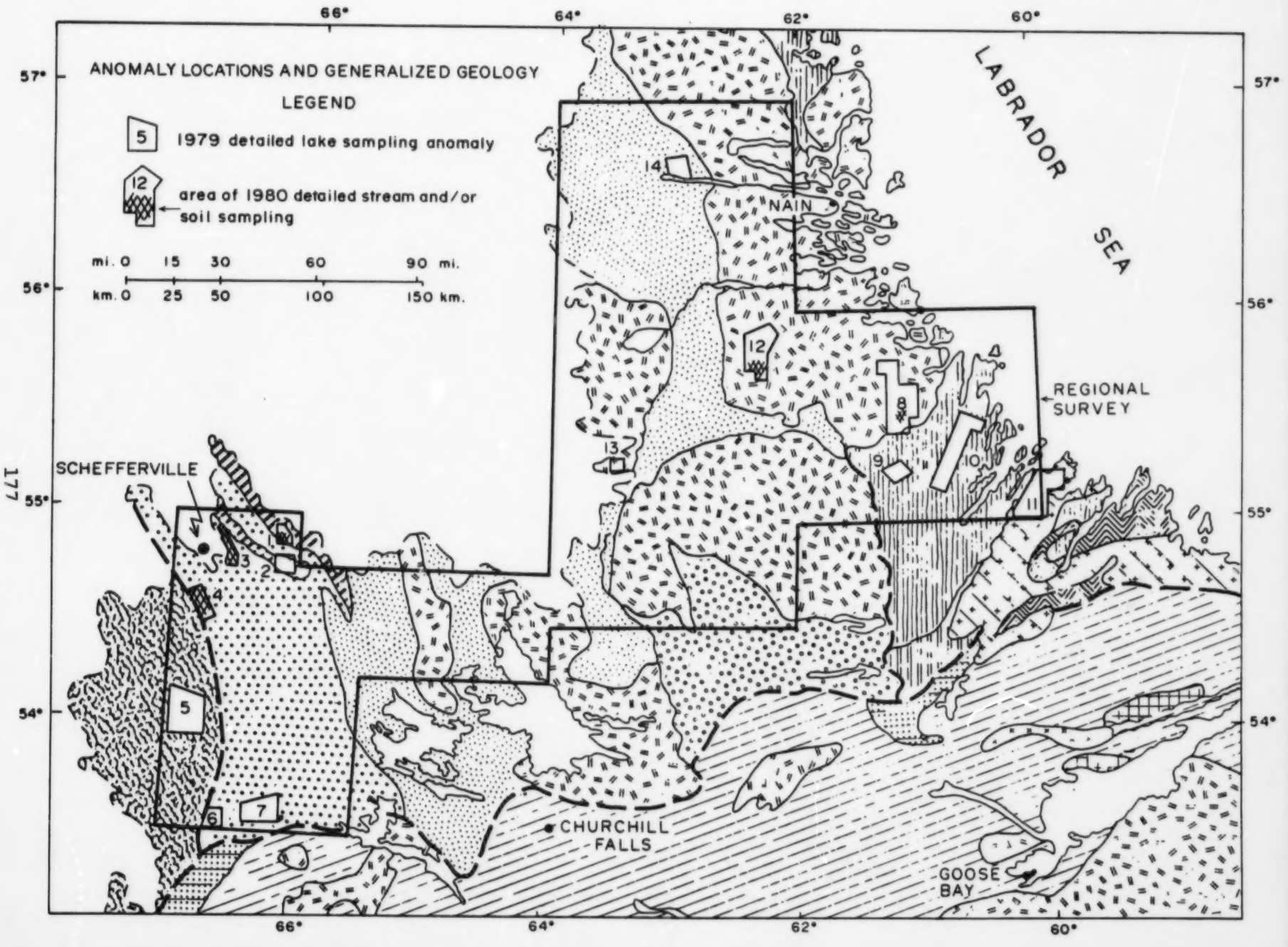
INTRUSIVE ROCKS

HELIKIAN — Anorthosites, gabbros and associated acidic intrusives and extrusives

HELIKIAN AND EARLIER — Massive to poorly foliated acidic intrusives

APHEBIAN — Acidic intrusives and associated metamorphic rocks

Gabbroic sills


ANOMALY LOCATIONS AND GENERALIZED GEOLOGY
LEGEND
5
1979 detailed lake sampling anomaly
12
area of 1980 detailed stream and/or soil sampling
mi. 0 15 30 60 90 mi.
km. 0 25 50 100 150 km.
66°
64°
62°
60°
57°
56°
55°
54°
LABRADOR SEA
NAIN
SCHEFFERVILLE
REGIONAL SURVEY
CHURCHILL FALLS
GOOSE BAY
177

than veins are present. Although little time was spent on the northern area, the little mineralization found there seemed related to shear zones in the granite with wider widths of lower radioactivity than is typical in the southern vein-type occurrences.

Fist-sized grab samples of rock collected along a sampling "traverse" running perpendicular to one of the most radioactive veins gave the assays and analyses shown in Table I below.

This particular vein is on a cliff face and its lateral extent could not be determined, but its radioactivity decreases sharply within a few metres in a vertical direction. Several other less radioactive veins were found nearby. Another area about 1 km to the northeast is host to several veins with most scintillometer readings being about 25% as high as this vein. One vein in this second area, however, gave scintillometer readings equal to or slightly higher than the analyzed vein. Its lateral extent is bounded by overburden but exceeds 2 metres.

Autoradiographs and X-ray diffraction analyses of vein and wall rock material corresponding to sample 40027 indicate the dominant uranium bearing mineral to be uraninite (pitchblende) with lesser amounts of kasolite, a secondary U-Pb silicate derived from the weathering of pitchblende (J.A. Kerswill, Geological Survey of Canada).

Generally, no visible alteration is associated with the veining, although quartz veins are present in a few instances and slight gossan streaks occur in others. Spectrometer analyses indicate extremely low thorium concentrations relative to uranium.

Stream Sampling. Stream samples were collected at 250 m intervals. The minus 80 mesh fraction of the dried sediments was analyzed for U, Pb, Zn, Co, Ni, Ag, Mn, Fe, Mo, F and loss-on-ignition (LOI) as a measure of the organic content. Waters were analyzed for pH, U and F. Sediments were analyzed for U by a delayed counting neutron activation technique and waters were analyzed fluorimetrically.

In both sampling media, U gives the best indication of U mineralization in the rocks upstream of sample sites. The concentration of U in sediments, however, was found to be strongly correlated with the LOI. Therefore, this variation should be removed as much as possible by some statistical technique such as linear regression before the U in sediment data is used as a guide to mineralization.

The survey results including a text, data and maps from this anomaly were released as Labrador Open File 13M/12 in October, 1980.

TABLE I

Sample	Assay/Analysis	Comments
40027	1.81% U_3O_8	Sample of vein and wall rock material
40028	0.13% U_3O_8	Sample of wall rock 6-12 cm from vein center
40029	11.9 ppm U	Sample of wall rock 30 cm from vein center
40030	6.2 ppm U	Sample of wall rock 1.2 m from vein center

DIMENSION STONE AND MINERAL FILLER ASSESSMENT

by

D.M. Watson

DIMENSION STONE

This was the first year of a two-year program to evaluate the dimension stone resources of Insular Newfoundland. During the past season, an attempt was made to visit, examine and sample all potential sources of stone of the Island. This objective was reached after travelling in excess of 30,000 km.

MINERAL FILLERS

In addition to building and dimension stone, potential sources of mineral fillers were also visited and sampled. These included many of the same materials as the dimension stones, but usually with less rigid standards as to physical properties of the stone.

DEFINITION OF TERMS

Granite: When used in the general sense, granite refers to any igneous or metamorphic rock (except ones of obvious sedimentary origin such as marble or quartzite). It includes granite, syenite, anorthosite, diorite, gabbro and various gneisses derived from these rocks.

Marble: Like the term granite, marble is used to refer to a variety of rocks that may not be marble in the strictest sense. It may be used to refer to marble, limestone, dolomite, and other sedimentary and metamorphic carbonate rocks.

RESULTS

(a) Dimension Stone

Granite (white, pink and red): All of the previously quarried granites in the province have potential for future development. They all possess reserves that may be removed in large (8 m^3) blocks, and that appear suitable for dimension stone use.

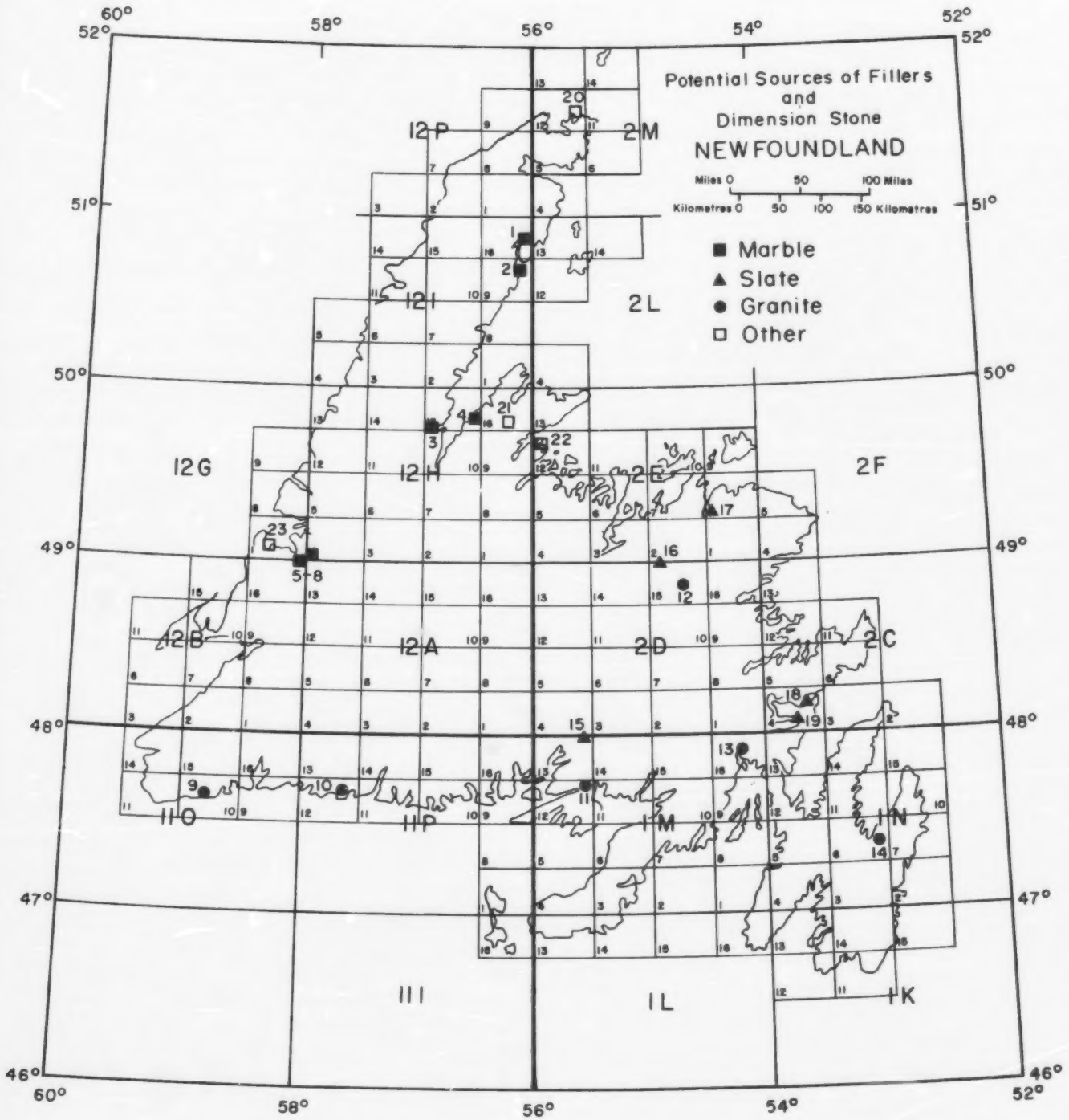
In addition, granites found at Swift Current, Gambo-Middle Brook, Wesleyville, Gander, Harbour Breton and Burgeo appear promising. Preliminary examination of these locations suggests that stone would be available in large blocks; initial polishing tests indicate that the stone would polish well.

Several other locations contained stone of good quality, but it is doubtful whether large blocks could be quarried.

Granite (black): There are few sources of dark stone suitable for dimension stone uses. The majority of otherwise suitable stones are too severely jointed and/or fractured to be used. In other cases, the stones are highly serpentinized and could not be easily sawn and polished.

At one possible source along the Baie d'Espoir Highway, dark stone occurs in large blocks; this stone is quite attractive when polished. However, it weathers to an unpleasant rusty brown color in a short time (less than 5 years). This process may be accelerated on broken surfaces, and may not be serious in polished pieces, or in stone used indoors. More testing needs to be done to test this stone.

Marble: Although there are many sources of marble on the island, many of which are very attractive when polished, few could be obtained in large enough pieces for dimension stone use. The marbles of the Corner Brook and Sop's Arm areas could be used for such purposes as trophy bases, small ornamental objects, and any other project not requiring large pieces.


Potential Sources of Fillers
and
Dimension Stone
NEWFOUNDLAND
Miles 0 50 100 Miles
Kilometres 0 50 100 150 Kilometres
Marble
Slate
Granite
Other
60°
58°
56°
54°
52°
51°
50°
49°
48°
47°
46°
12P
2M
12I
2L
12G
12H
2E
2F
12B
12A
2D
2C
11O
11P
1M
1N
11I
1L
1K

If care was exercised in mining, it is possible that larger blocks could be obtained from some of the locations after removal of the surface material.

Slate: Slate has been quarried on the island in the past, and could probably be quarried again at the former sites. These are at Random Island and Smith Sound in the Clarenville area. In addition, slate suitable for facings and flooring could be obtained from the St. Alban's and Gander Bay areas. In other areas, the slate observed was either not of good enough quality, or was in beds of insufficient thickness to be commercially attractive. These other occurrences, however, could provide slate for mineral fillers.

(b) Mineral Fillers

Besides sampling and noting the occurrence, no work has been done to evaluate the marbles and slates of the Island for their potential as ground fillers. As already noted, many of the slate occurrences visited as well as many of the marbles are not suitable for use as dimension stone but could be used as fillers. The samples collected from these sites will be ground and subjected to the appropriate physical and chemical tests during the winter.

INVENTORY OF AGGREGATE RESOURCES

by

R.J. Ricketts, F.T. Kirby and D.G. Vanderveer

INTRODUCTION

The Inventory of Aggregate Resources in Newfoundland was begun in 1975 as part of the Surficial and Glacial Mapping Program. In 1977 a separate sampling program conducted analyses in areas previously mapped surficially (Vanderveer, 1977; Grant, 1973; and Brookes, 1974). This program was supplemented in 1977 by sampling conducted by the Surficial and Glacial Mapping Program (Vanderveer and Sparkes, 1978).

The 1980 project has been a continuation of project 2.2 of the Inventory of Aggregate Resources program begun in 1978 and is funded under the Canada/Newfoundland Mineral Development Subsidiary Agreement. The program is designed to provide an inventory of aggregate (sand, gravel, crushed stone, stone, ballast) resources along existing and proposed transportation routes in Newfoundland and Labrador and will show the location, size, quality, present degree of use, and potential of each deposit.

During 1980, mapping in Insular Newfoundland (Map I) was concentrated in the following areas: Cormack, Main Brook, Burgeo Road, and Fogo Island. Also included in the survey were a number of hydroelectrical developments: Upper Salmon - under construction; and Lake Michel, Cat Arm and Dry Pond - proposed developments.

Areas sampled in Labrador (Map 2) were as follows: (a) the proposed road link between North West River and the Kitts-Michelin sites (Makkovik area), (b) the completion of reconnaissance begun in 1979 of a proposed transmission line route between Gull Island and Forteau, (c) all southern Labrador roads, (d) the road system around Wabush and Labrador City, (e) infilling work along the transmission line between Twin Falls and Labrador City, and (f) complete corridor sampling along all of the QNS&L Railway Line within Labrador.

FIELD PROGRAM

A 6 km wide corridor (Maps 1 & 2) centered and parallel to existing, proposed, or partially constructed highways and secondary roads in Newfoundland and Labrador and the QNS&L Railway Line has been covered. Tertiary roads and trails capable of being upgraded to handle truck traffic were included in the corridor and sampling extended for a distance of 8 km along these from the main road.

During 1980, extensive helicopter support was needed in sampling isolated areas. Highway and all-terrain vehicles were used for most of the work along roads and rail lines in western Labrador. In areas of potential aggregate resources (*e.g.* glaciofluvial, fluvial, deltaic, marine or esker deposits), foot traverses were carried out. These traverses extended 3 km from the road or rail line with samples taken every 0.5 to 1 km in areas of aggregates.

Additional samples were obtained where deposit changes occurred or quality differences were apparent at any given location; *i.e.*, where products could be quarried separately. In areas lacking potential sand and/or gravel material, morainal and bedrock materials were sampled; *i.e.*, one sample per 1 to 2 km, except where the varying nature of the deposit required additional sampling.

Generally, sample sites were limited to existing natural (stream or coastal cuts) or man made (road cuts, pits and quarry excavations, etc.) exposures. In areas of potential aggregate resources, shallow pits were hand dug if no other exposures existed.

All field and sieve data for 1980 were placed on two separate forms. Form I gives general site information including data on location, landforms, stratigraphy, ice movement indicators, and notation for photo numbers and extra notes. Form II gives a field description of the sample, plus data on field sieve analyses, field pebble analyses and a section for laboratory sieve analyses.

Field sieve analyses were conducted on all samples containing +8 mm size material. Moisture tests were usually conducted on every second or third sample if the deposit remained consistent along the traverse route; otherwise, analyses were done at every sample location. During sieve analyses, approximately 10 to 20 kg of material was sampled, weighed and sieved through a bank of four 30 cm diameter sieves (sizes 63 mm, 31.5 mm, 16 mm and 8 mm). The total sample weight and the weights retained on each field sieve and canvas were recorded on Form II. A 200-500 gm split of the -8 mm sand-silt/clay fraction was retained for laboratory sieve analyses. If a sample had a high silt-clay content and/or a high moisture content, it was wet sieved; *i.e.*, washed through the bank of field sieves. The -8 mm size fraction for laboratory analyses was then taken from the exposure site. A split (100-200 pebbles) of the +16 mm retained pebble fraction of each sieved sample was saved for the field pebble lithological study. A bulk sample (500-1000 gm, minus any larger stones) was taken and returned to the laboratory for sieve analyses when sieve analyses were not conducted in the field. All samples were taken from fresh unweathered exposures and from below the normal soil horizon wherever possible. Where exposures permitted, channel sampling or multiple spot sampling was used to ensure a representative sample.

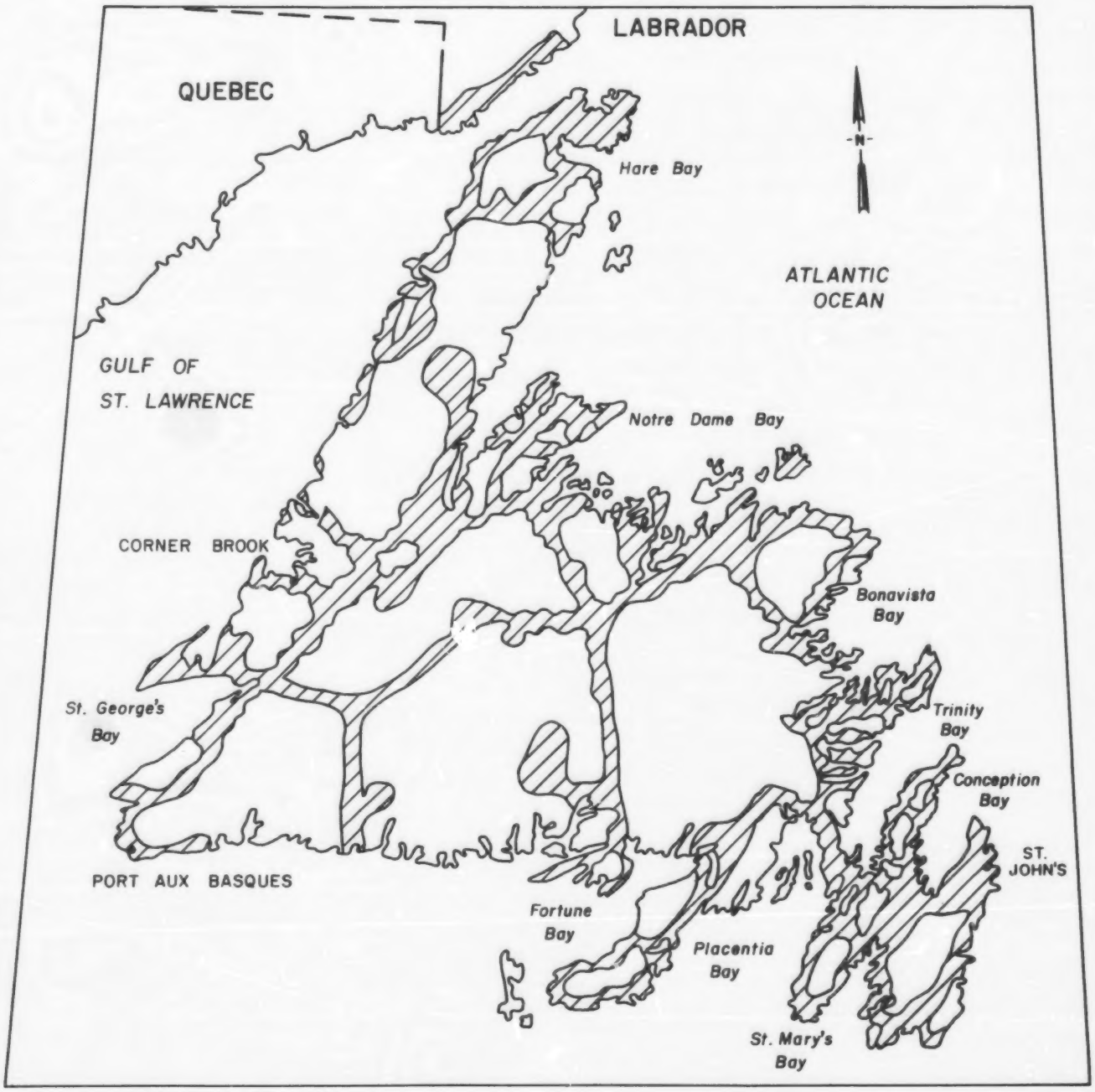
More detailed experimental sampling projects have been carried out on gravel deposits in Butt's Pond and Sandy Brook areas. These projects were designed to assess the feasibility of such projects in areas where the nature of the terrain or deposit characteristics would yield inadequate data if normal sampling procedures were used. Also, such detailed information has become essential in planning sequential land use development in high demand areas.

Samples for these projects were taken at 50-250 m intervals, to more accurately delineate horizontal and vertical depositional changes. A backhoe was used extensively in order to define the depth characteristics of the deposits. Depths reached with the backhoe were normally 2.7 to 3.2 m, although at Sandy Brook depths of 7 m were not uncommon.

LABORATORY PROGRAM

The laboratory program consists of sieve analyses of the sand-silt/clay (-8 mm) fraction of each sample returned from the field. These analyses consisted of drying and splitting the sample to a manageable size (70 to 140 gm) then sieving through a bank of seven sieves (4 mm, 2 mm, 1 mm, 0.5 mm, 0.25 mm, 0.125 mm and 0.062 mm) for each sample of gravel or sand, *i.e.* samples not containing much silt and/or clay material. The weights retained on each sieve and in the pan were recorded on Form II.

Glacial tills and other samples of a high silt and/or clay content were treated as follows: the sample was (1) dried and split to 70 to 140 gm; (2) deflocculated using a few drops of a solution of hydrogen peroxide (3% percent H_2O_2); (3) wet sieved through the 0.062 mm sieve; (4) the plus 0.062 mm sand fraction was dried and sieved,



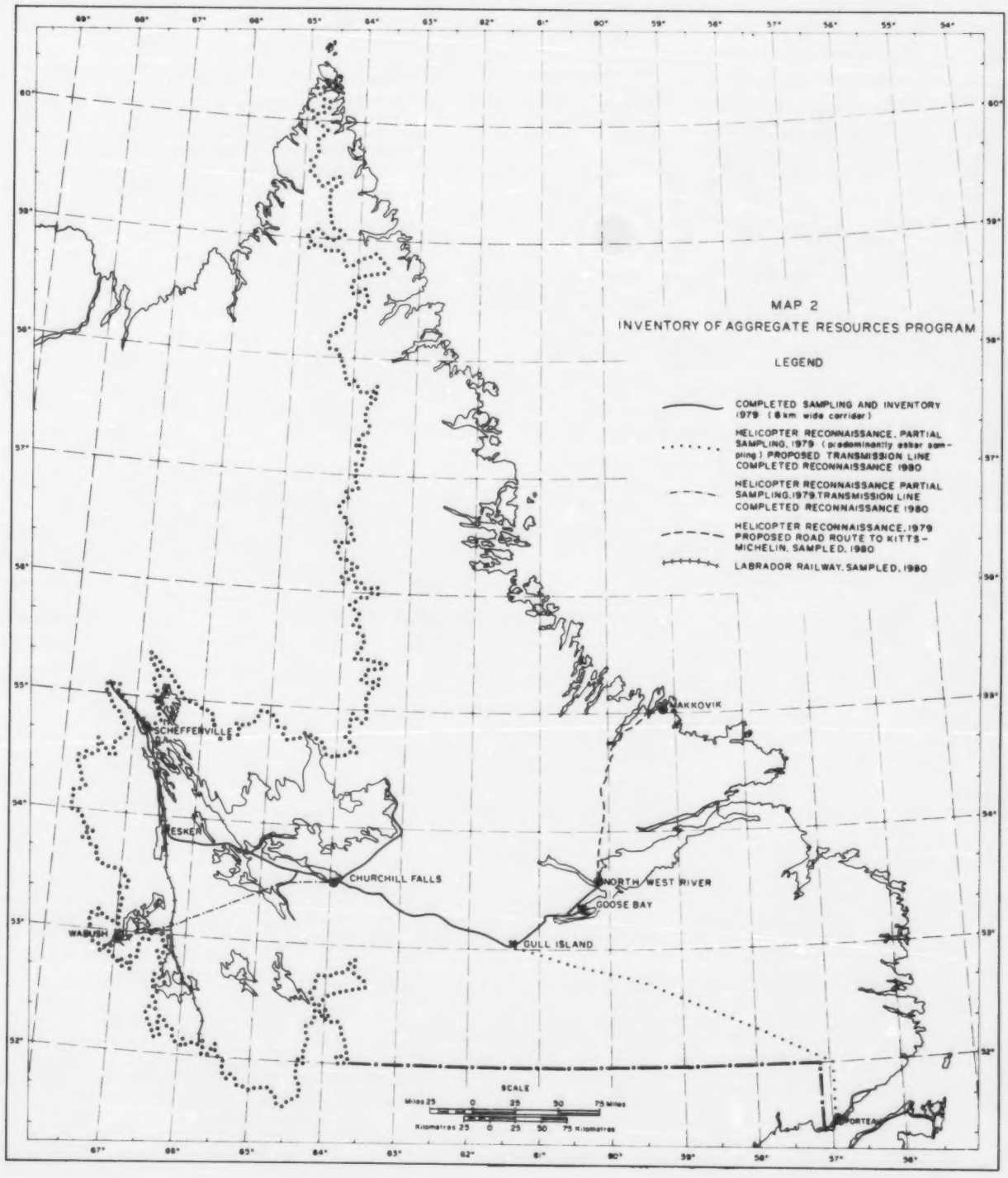
MAP 1

Inventory of Aggregate Resources Program
Island of Newfoundland
CANADA/NEWFOUNDLAND MINERAL DEVELOPMENT SUBSIDIARY AGREEMENT
SUBPROJECT 2.2

Legend

Completed 6 km wide corridor sampling parallel to existing roads and highways, and selected development areas

Unsurveyed areas include Gros Morne and Terra Nova National Parks


MAP 2
INVENTORY OF AGGREGATE RESOURCES PROGRAM
LEGEND
COMPLETED SAMPLING AND INVENTORY 1979 (8 km wide corridor)
HELICOPTER RECONNAISSANCE, PARTIAL SAMPLING, 1979 (predominantly esker sampling) PROPOSED TRANSMISSION LINE COMPLETED RECONNAISSANCE 1980
HELICOPTER RECONNAISSANCE PARTIAL SAMPLING, 1979 TRANSMISSION LINE COMPLETED RECONNAISSANCE 1980
HELICOPTER RECONNAISSANCE, 1979 PROPOSED ROAD ROUTE TO KITTS-MICHELIN, SAMPLED, 1980
LABRADOR RAILWAY, SAMPLED, 1980
SCHEFFERVILLE
ESKER
CHURCHILL FALLS
WABUSH
GULL ISLAND
AKKOVIK
NORTH WEST RIVER
GOOSE BAY
PORTEAU
SCALE
Miles 25 0 25 50 75 Miles
Kilometres 25 0 25 50 75 Kilometres

and the data recorded as with sand and gravel samples and; (5) the minus 0.062 mm fraction (water and silt and clay) was flocculated and settled by adding a small amount of magnesium chloride (1N $MgCl_2$), the excess water removed and the resultant silt-clay mixture dried, weighed and this data also recorded on Form II.

All field and laboratory data will be stored on computer for ease of retrieval.

LITHOLOGIC STUDY

Pebble lithology studies conducted in 1980 consisted of a review of the geological literature of each study area, the selection of a reference collection of rock specimens for each study area, and the determination of the percentage of each rock type found in each sample of pebbles.

A reference collection of bedrock samples was compiled during the field traverses for each study area as an aid to the pebble lithology investigations. The pebble lithologic studies also included information on the silt/clay coating, weathering, staining, sphericity, rounding, fracturing, mineralogy and texture for the various lithologies present in the pebble samples. A brief report will be written concerning this study for each area investigated.

RESULTS

During the 1980 field season, 978 samples were collected. The breakdown of these samples was as follows: tills - 366, gravels - 246, sands - 258, silt - 20, clay - 14, rock - 72, and organics (including peat, shells and fossils) - 2.

Field pebble lithology studies were conducted on approximately 425 pebble samples collected during 1980.

Sampling in 1980 was carried out in the following map areas: Insular Newfoundland (1M/13; 2E/9; 11P/12-14, 16; 12A/1,4,5,8; 12H/6-8,10,15; 12I/2,3, 6,11; 12P/1,8); Labrador (12P/6,7,9,11, 14,16; 13A/4; 13B/1,7,10; 13F/2,7,9,1; 13J/5,12,14; 13K/1,8,9; 13O/3; 23A/4,5, 12; 23B/9,14,16; 23G/1,2,8,9,16; 23H/4,7; 23J/1,2,7,10,15).

With the completion of the 1980 field program, all major existing and proposed transportation routes in Insular Newfoundland and Labrador have been covered (Maps 1 and 2). For a complete list of map areas covered prior to 1980, refer to Report 80-1 (Kirby *et al.*, 1980).

Analyses of all field data collected prior to 1980 should be completed by the time of this printing and will be available upon request.

Data from the 1980 program will be released as it becomes available. An outline of potential areas of aggregate materials and the locations of all samples will be plotted on 1:250,000 topographic base maps for publication during 1981. These data will also be recorded on 1:50,000 base maps for release upon request.

When the laboratory analyses program is completed on the samples collected during 1980, data will be available for 8286 samples collected since 1975, and covering a substantial part of Insular Newfoundland and Labrador.

Work is progressing on a computer package that will report on all coded field and laboratory data in an "english-like" format and enable the search and retrieval of selected data for various users and for various purposes.

ACKNOWLEDGEMENTS

We wish to thank Ben Warren (senior assistant), Martin Ricketts (geological assistant), Dan Bragg (field lithologi-

cal investigator), Richard St. Croix and Ted Butt (junior field assistants), and Bev Wareham (laboratory technician) for their dedicated assistance during 1980.

REFERENCES

Brookes, I.A.
1974: Late Wisconsin glaciation of southwestern Newfoundland (with special reference to the Stephenville map area). Geological Survey of Canada, Paper 73-40.

Grant, D.R.
1973: Surficial geology maps, Newfoundland (11 maps). Geological Survey of Canada, Open File 180.

Kirby, F.T., Ricketts, R.J., and Vanderveer, D.G.
1980: Inventory of Aggregate Resources. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 249-256.

Vanderveer, D.G.
1977: Surficial and glacial mapping-gravel resource inventory. *In* Report of Activities for 1976. *Edited by* R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 77-1, pages 90-95.

Vanderveer, D.G. and Sparkes, B.G.
1978: Surficial and glacial mapping. *In* Report of Activities for 1977. *Edited by* R.V. Gibbons. Department of Mines and Energy, Mineral Development Division, Report 78-1, pages 179-182.

STAR LAKE - VICTORIA LAKE SURFICIAL AND GLACIAL MAPPING, NEWFOUNDLAND

by

B.G. Sparkes

INTRODUCTION

During 1980, mapping was conducted on the Star Lake (12A/11) and Victoria Lake (12A/6) map areas of Newfoundland (Map 1). This project was a continuation of the Surficial and Glacial Mapping Program in the Central Volcanic Belt designed to provide information as an aid to mineral exploration. (Vanderveer and Sparkes, 1979; Sparkes and Vanderveer, 1980). This area was chosen because of its recognized mineral potential, recent exploration activity, scattered occurrences of mineralized float, and thick and extensive cover of overburden. The area has limited access and relatively few till exposures or unweathered bedrock exposures exhibiting glacial flow indicators.

FIELD PROGRAM

Mapping was started in June and continued until September. Information was obtained along existing roads, lake shorelines and streams. Fifty pits were dug to obtain samples and to provide suitable exposures to do till fabrics. During the summer, 385 sites were noted and 40 sets of striae recorded, with directions and/or relative ages assigned to most of these. There were 175 till samples taken for particle size analysis and geochemistry, and a representative pebble fraction was obtained to determine the lithologic composition of the tills. This lithologic study also included information on the silt/clay coating, weathering, staining, sphericity, fracturing, mineralogy and texture for the various lithologies present.

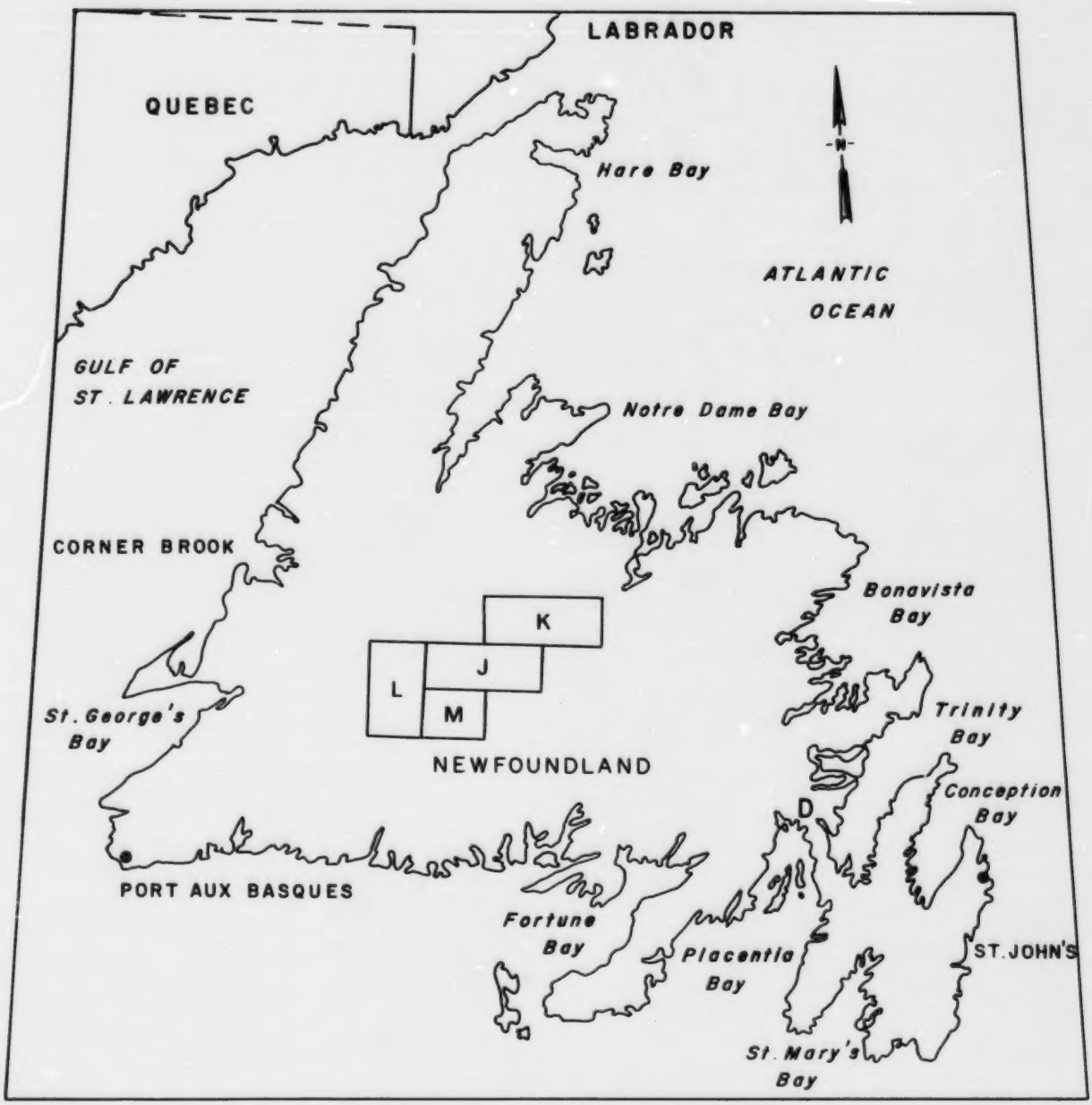
GLACIAL STRIAE

Throughout the area, two major sets of striae have been recorded, one set at 160-195 and a second set at 220-270. In all cases, where directions have been assigned to these striae, one or more of the following indicators have been used: (a) miniature crag and tail, (b) crescentic or lunate fractures or gouges, (c) nail head features, and (d) miniature stoss and lee forms.

Stratigraphy

A limited number of exposures of glacial stratigraphy are located in the Lloyds River and Tulk's River Valley areas and on the Victoria Lake shoreline. Elsewhere the exposures reveal only a single stratigraphic unit usually overlying bedrock.

Approximately 3 km down river from Lloyd's Lake, till overlies coarse outwash gravel which in turn overlies gently dipping silt/clay rhythmites. Further down river, a very blocky local till overlies sand. Another exposure reveals gravel overlying till which in turn overlies interbedded gravel and sand. Near the mouth of Lloyd's River a sandy loose till overlies sand and gravel, which in turn overlies silt/clay rhythmites underlain by a very compact or 'cemented' clay-rich, red to gray, till. Near the mouth of Tulk's River a silty gray-brown till overlies silt/clay rhythmites with minor folds. This same sequence is repeated at several localities along the Tulk's River Valley. On the north shore of Victoria Lake, near the western edge of the map

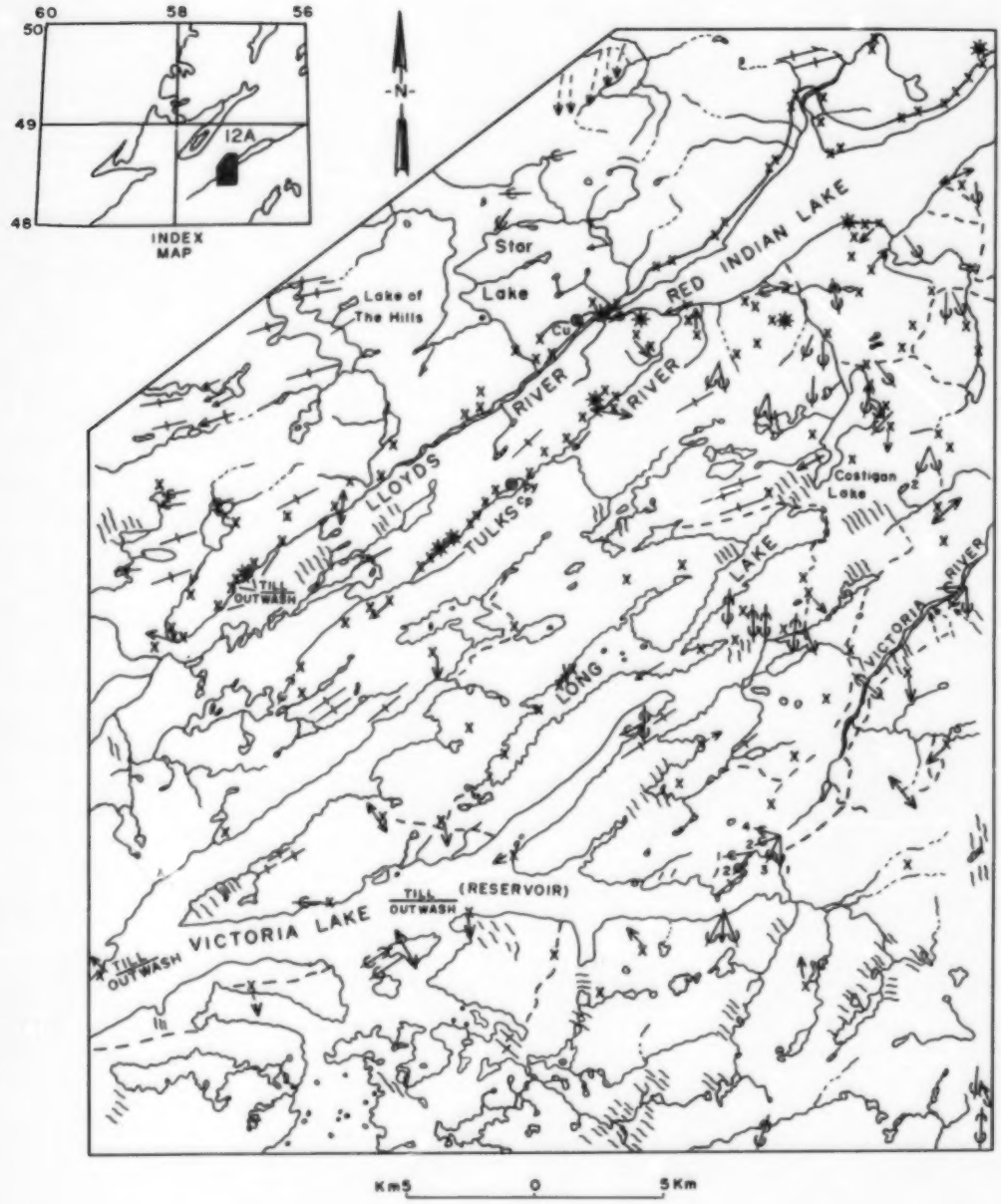


MAP 1

J. Lake Ambrose - Noel Paul's	(1978)	O.F. 12A (212)
K. Badger - Grand Falls	(1979)	O.F.NFLD (93)
L. Star Lake - Victoria Lake	(1980)	
M. Proposed Mapping	(1981)	

Star Lake - Victoria Lake, Surficial and Glacial Mapping

MAP 2



LEGEND

Glacial striae (direction of ice movement known, unknown) . . . . . .

Number indicates relative age, 1 being the oldest. . . . . . .

Till fabrics (ice direction known, unknown . . . . . .

Esker (direction of flow known, unknown) . . .

Minor moraines, rib moraines, washboard moraines, annual moraines, till ridges transverse to ice flow (irregular, straight) . . . . .

Drumlins and drumlinoid ridges . . . . . .

Sample sites . . . . . .

Glacial linear feature . . . . . .

Glacial meltwater channel . . . . . .

Roche moutonnee . . . . . .

Rhythmite locations . . . . . .

Mineralized float occurrences. . . . . . .

area, a gray-brown till overlies interbedded gravel, silt, and sand, and on the south shore, 15 km to the east, a similar till overlies a contorted silt/sand sequence.

Glacial Interpretation

The glacial history of the area, based upon the information compiled, indicates as follows: (1) the southerly (160-195) flow of ice covered most or all of the area and was an early event (Map 2). This flow probably had its source in the area to the northwest of Red Indian Lake, and was related to the southerly flow of ice mapped in the Lake Ambrose area (Vanderveer and Sparkes, 1979). The 'cemented' clay-rich, red to gray till may have been deposited with the flow; (2) Subsequent to this, there was a regression of ice to the north of Red Indian Lake, and (3) there was deposition of glaciofluvial and glaciolacustrine sediments while the lake was dammed, possibly at some point along its length and the water was above its present level due to the influx and draining of meltwater. (4) The next recorded ice flow was to the west and southwest and is well expressed in striations, and a general stossing of outcrops, particularly in the areas of Long Lake, Victoria Lake, and Victoria River. Some of the till fabrics in these areas also indicate this ice movement. The till deposited from this advance, is quite variable in texture and color and is generally immature.

The till overlying some glaciofluvial deposits in the Lloyd's River Valley and the Victoria Lake area, may be the result of a late readvance, and not associated with the general southwest flow. Similarly it has not been possible to determine whether there was a significant time gap between the deposition of the 'cemented' till, the overlying sediments, and the youngest till unit. Further investigations of the pebble lithologies, till fabrics, and textural analysis of the tills are planned.

ACKNOWLEDGEMENTS

The author thanks Roger Jackson, Paul Skeard and Glenn Squires for their diligent work during the field season.

REFERENCES

Sparkes, B.G. and Vanderveer, D.G. 1980: Badger-Grand Falls area - Surficial and glacial mapping. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 257-264.

Vanderveer, D.G. and Sparkes, B.G. 1979: Lake Ambrose-Noel Paul's Brook area: Surficial and glacial mapping. *In* Report of Activities for 1978. *Edited by* R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 79-1, pages 197-205.

QUATERNARY MAPPING - UPPER HUMBER RIVER AREA

by

D.G. Vanderveer

The area mapped is bounded on the west by the Long Range Mountains, on the south by the Trans Canada Highway, on the east by the Hampden road and on the north by the Sops Arm - Jackson's Arm access road, and covers parts of map areas 12H/3, 7, 10 and 11, and all of map area 12H/6. The mapping was carried out following questions by Westfield Minerals Limited concerning the late Quaternary glacial flow in the area. Westfield has located numerous boulders containing significant amounts of uranium mineralization. This glacial mapping program should be an aid in the search for the source of these boulders.

This program is the first "detailed" survey of the glacial history of the Upper Humber River area, although previous researchers working in surrounding areas may have made references to the glaciation of this area. These workers include MacClintock and Twenhofel (1940), who indicated northward ice flow out of Sandy Lake and Grand Lake; Lundqvist (1965), who showed early eastward and later southeast flow in the Sops Arm area; Grant (1973, 1974), who (a) showed northward trending crag and tail hills north of Sandy Lake (Map 12H/7) but also southward directed meltwater channels in the same area, (b) northwest flow near Bonne Bay Big Pond (Map 12H/5), (c) south to southeast directed meltwater channels along the north shore of Deer Lake (Map 12H/4), and (d) an ice front across Deer Lake with a center presumably to the north; and finally Rogerson (1979), retained by Westfield, who recognized the confused "state of the art" in the area, but concluded that ice flow was first to the north or northeast, then later to the northwest, away from Birchy Ridge.

A detailed interpretive analysis of the surficial and glacial geology was carried out on 1:50,000 scale aerial photography of the field area, followed by regional mapping, "ground truthing" and supplemented extensively by test pitting and sampling in the area of one of the main float occurrences. A backhoe was frequently provided by Westfield and Dave Hoover of Westfield collected numerous samples to aid this mapping program. This assistance was greatly appreciated.

RESULTS

Two major glacial events are recognized from the glacial striae of the area. The first event consists of eastward directed glacial flow which affected at least the area to the north of Wigwam Brook (Figure 1). This ice was presumably based in the Long Range Mountains. The second event(s) is south to southeastward directed glacial flow down the basin towards Deer Lake. Related to this second event is topographically controlled late ice and the possibility of a readvance from the northeast across Birchy Lake that (a) built four large moraines southwest of Birchy Lake, (b) overran glaciofluvial sediments south of Birchy Lake, and (c) left an extensive network of meltwater channels northeast and east of Birchy Lake.

Glaciofluvial sediments and meltwater channels on the range of hills southwest and south of Adies Pond indicate that glacial meltwater outflow from this pond was interrrupted, and the lake dammed until the waters of this proglacial lake flowed over the top of these hills. It has not been possible to determine if this event was related (1)

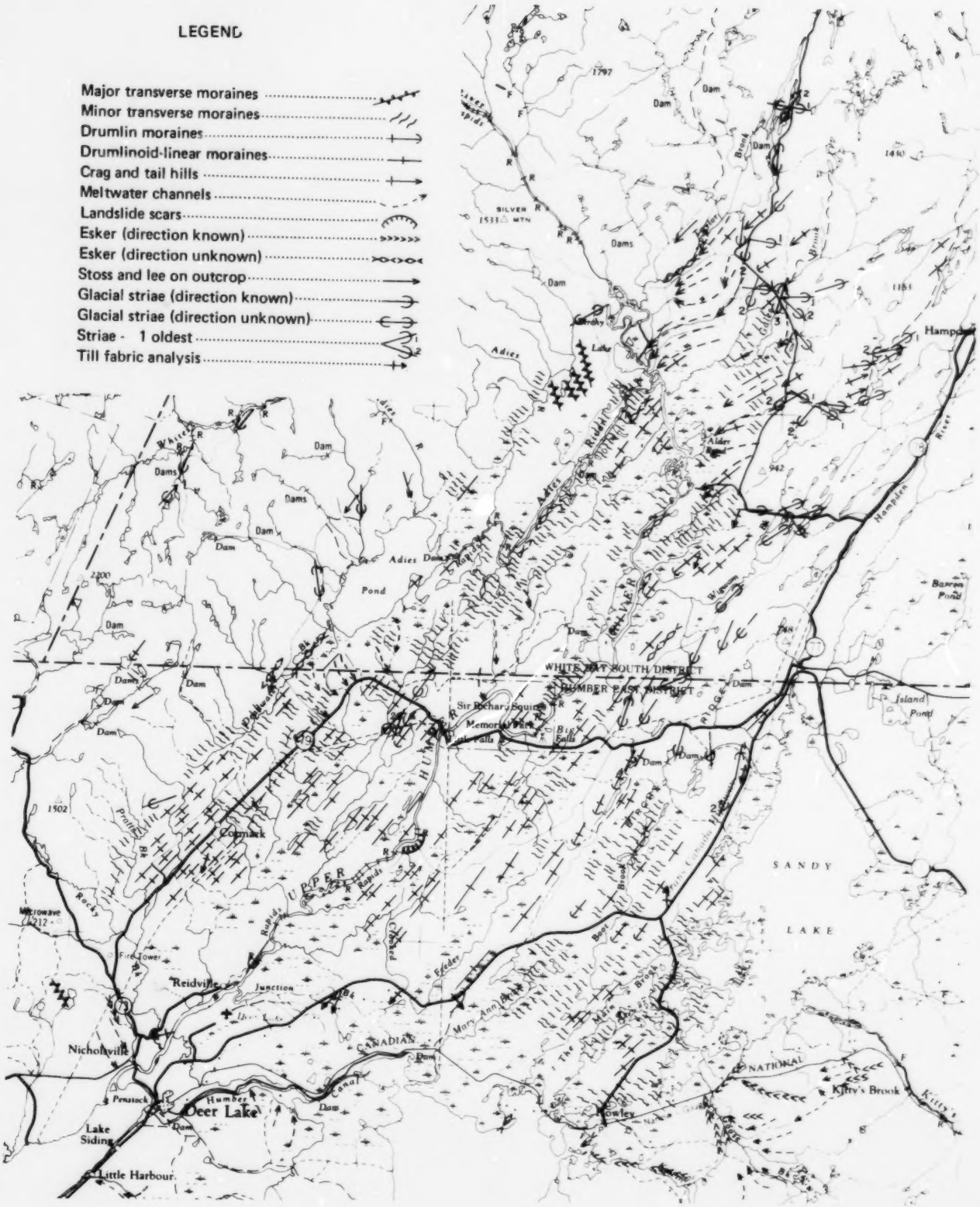


FIGURE 1

QUATERNARY MAPPING–UPPER HUMBER RIVER AREA
D.G. VANDERVEER – 1980

to the readvance that built the moraines near Birchy Lake, (2) to the retreat of the major glacial advance southeast through the basin, or (3) to the advance of valley glaciers off the Long Range Mouontains.

Glacial stratigraphy in the area is normally as follows:

(a) A light pinkish gray sandy till related to the easterly movement of ice off the Long Range Mountains. In the area east of the Sops Arm access road, this till contains some erratics of red sandstone that were derived from the lowland area to the west. A similar type of till also occurs in the southern part of the study area in the vicinity of the Trans Canada Highway east of Deer Lake.

(b) Throughout the main part of the basin, the normal basal till unit (as confirmed by drill core recovery) is a red clay-rich till that contains numerous gabbroic erratics, most likely derived from a gabbro complex located to the north of the study area.

(c) A local immature till, related to the lithologies of bedrock present in the immediate vicinity of deposition, usually overlies the red clay till although in some areas a glaciofluvial deposit of sand, gravel and/or silt may separate the two tills. In areas of dominantly red sandstones, this local till is very angular, sandy and red. In the vicinity of mudstones and shales, the till is usually brown, gray or red depending on the color of the bedrock and in some cases may include blebs or blocks of any other till unit that it may overlie.

Till fabric analyses of the basal red clay-rich till indicate transport generally to the south and southeast. Fabric analyses in the overlying local till units are generally inconclusive because of the lack of development in the till and the lack of comminution within the till unit.

An analysis of terrain, landforms, meltwater channels, etc. has led the author to tentatively conclude that the source of ice that deposited the upper local till unit was located to the north and northeast. Further work shall include textural analyses of the various till samples collected and release of the 1:50,000 scale surficial maps.

REFERENCES

Grant, D.R.
1973: Surficial Geology maps, Newfoundland. Geological Survey of Canada, Open File 183.

1974: Prospecting in Newfoundland and the theory of multiple shrinking ice caps. *In* Report of Activities, Part B. Geological Survey of Canada, Paper 75-1C, pages 333-334.

Lundqvist, J.
1965: Glacial Geology in Northeastern Newfoundland. Geological foren., volume 87, pages 285-306.

MacClintock, P. and Twenhofel, W.
1940: Wisconsin glaciation of Newfoundland. Geological Society of America Bulletin, Volume. 51, pages 1729-1756.

Rodgerson, R.
1979: Drift prospecting in the Deer Lake Lowland - a report prepared for Westfield Minerals Limited, Reidville, Newfoundland.

DRILL CORE STORAGE PROGRAM

by

C.J. Collins and B. Burt

During the 1980 field season, a program of diamond drill core collection was carried out. The emphasis this season was placed on insular Newfoundland with just two weeks spent in Labrador doing reconnaissance work. Field work consisted mainly of checking the sites of old diamond drilling. Many of these sites were more than twenty years old and did not yield any salvageable core. However, approximately 20,000 metres of core were collected (Table I). Most of this core has been placed in temporary storage facilities at Pasadena.

Construction of the St. John's core library has now been completed. We expect to start moving core into it this winter. The core library is located off Torbay Road near the airport (Figure 1). It has an approximate area of 450 square metres and storage capacity for approximately 60,000 metres of drill core as well as facilities for the storage of representative rock collections from geological mapping programs and mineral deposit suites. It has a laboratory for examining core and equipment for splitting, cutting and polishing samples. There will also be microscopes and photographic equipment for detailed petrographic work. Geoscience files, including drill logs, location plans, sections and indexes will be available for inspection.

These facilities will be available for use by exploration geologists, university researchers, the staff of the Department, and other interested persons.

Plans are also underway for core libraries at Deer Lake (Pasadena) and Goose Bay (Figure 2). A site near the "Dept. of Tourism" building in Pasadena has been chosen for that core library and funds for construction have been approved. It is hoped that construction can be started in the spring of 1981 with occupancy by the fall of 1981. This building will have an area of about 1000 square metres, adequate for the storage of about 200,000 metres of core.

In Goose Bay, it is planned to renovate an existing building on the old air base. A building has been selected and efforts are now being made to acquire the rights to it. This building is particularly suitable for core storage and can be used immediately for temporary storage of Labrador core. It has an area of about 600 square metres. We hope to renovate this building and have it operational as a permanent core library by the end of 1981.

Besides the construction, renovations, and core collection programs, our plans for 1981 include organizing the St. John's core library and developing a computerized diamond drill hole index (or inventory) system. To date, the collection program has accumulated more than 45,000 metres of drill core (Table I). The core is of a variety of sizes from various locations throughout the province (Figure 3). Of the total amount, approximately 15,000 metres are stored in St. John's with the remainder being temporarily stored at Springdale, Pasadena, and Goose Bay.

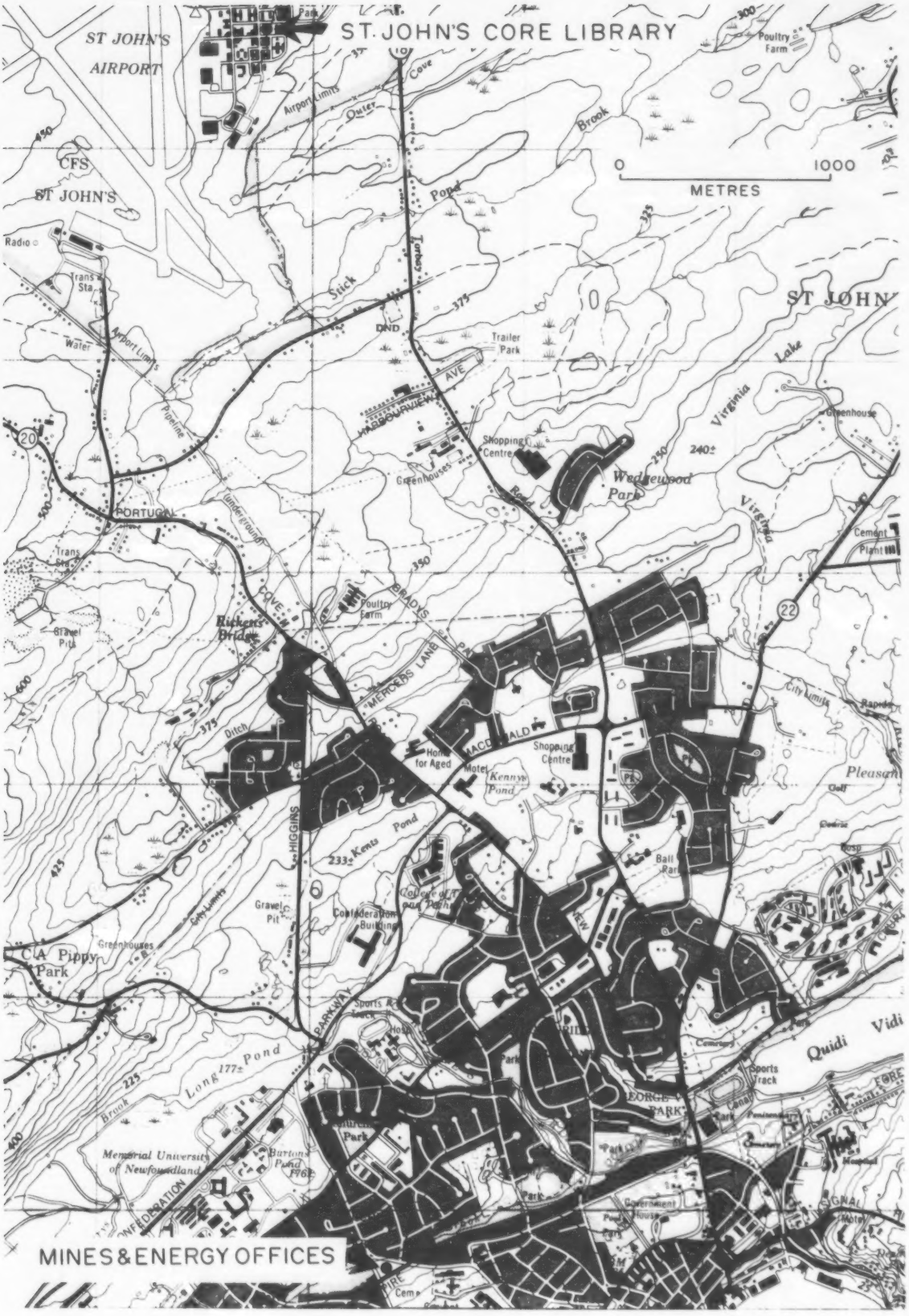

ST. JOHN'S CORE LIBRARY
MINES & ENERGY OFFICES
ST JOHN'S AIRPORT
CFS ST JOHN'S
0 1000
METRES
PORTUGAL
Wedgewood Park
Virginia Lake
Kenny's Pond
Long Pond
Quidi Vidi
Memorial University of Newfoundland
Confederation Building
Pippy Park
Bidgood Park
Bowring Park
Rawlins Cross
Government House
Trailer Park
Shopping Centre
Poultry Farm
Cement Plant
Greenhouses
Trans Sta
Gravel Pits
Ditch
Pond
Brook
Pipeline
Water
Radio
Motel
Golf
Ball Park
Sports Track
Cemetery
Hospital
Home for Aged
Trans Can Hwy
Airport Limits
City Limits
Outer Cove
Cove
Stick
Pond
Brook
Virginia
Lake
Pleasant
Quidi Vidi
Long Pond
Kenny's Pond

FIGURE 2
PROVINCE OF
NEWFOUNDLAND
Mi 20 0 20 40 60 80 100 Mi
CORE LIBRARIES
PROPOSED CORE LIBRARIES
Goose Bay
NEWFOUNDLAND
QUEBEC
Deer
Lake
St. John's

+1

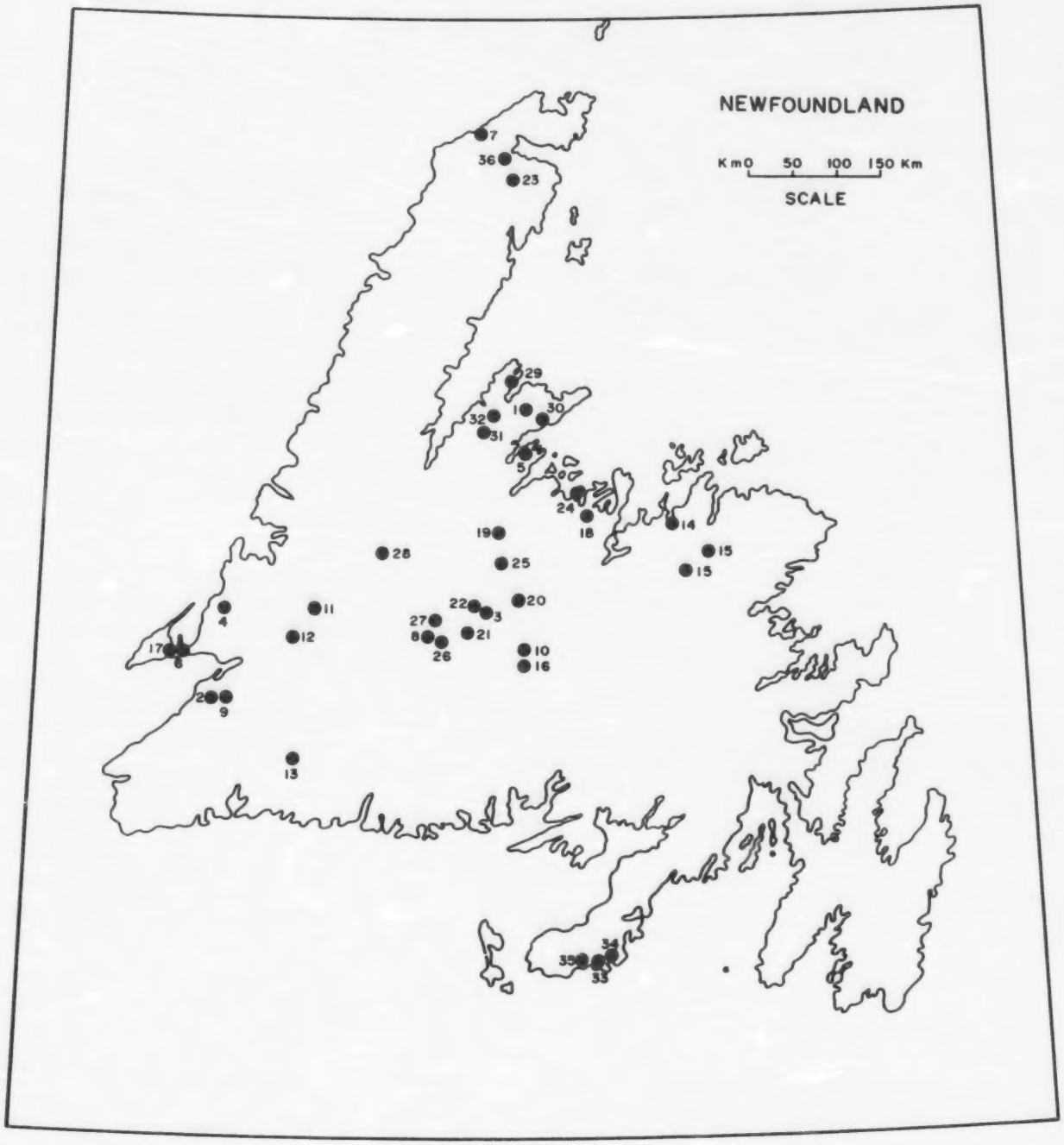


FIGURE 3. CORE COLLECTION SITES

TABLE I

SUMMARY OF CORE COLLECTED TO DATE

No.	Company	Year	Property	# of Holes	Total Metres
1	Advocate	1967	Rambler	2	1, 193.0
2	Amax	1976	Fischells Area	2	1, 420.3
3	Amoco	1978	Burnt Pond	4	609.6
4	Beth Canada	1978	Springer's Hill	10	911.7
5	Boylen-Cerro		Colchester	18	1, 379.2
6	Canadian Refractories	1970	Aguathuna	13	850.1
7	Chevron	1979	Eddies Cove	11	481.6
8	Cominco-Hansa	1973(?)	Bobby's Pond	5	431.6
9	Hooker Chemical	1968	Fischells	1	173.4
10	HBOG	1978	Gt. Rattling Bk.	11	818.6
11	HBOG	1978	Reid Lot 223	5	306.3
12	HBOG	1978	Reid Lot 225	2	117.0
13	HBOG	1978	Top Pond	1	47.1
14	International Mogul	1974	Campbellton Area	15	1, 394.5
15	International Mogul	1975	Gander Area	12	708.7
16	Minorex	1978	Atlantic Lake	6	439.5
17	Nfld. Dept. of Mines		Port au Port	?	811.5
18	Noranda	1972	Point Leamington	3	265.8
19	Noranda	1973	Gullbridge	1	54.9
20	Noranda	1975	Leonard's Lake	3	388.6
21	Noranda	1975-78	Tally Pond	4	489.2
22	Noranda	1978	Burnt Pond	2	165.0
08	Noranda	1978	Bobby's Pond	4	320.6
23	Shell	1975-76	Main Brook Area	32	1, 859.3
24	Texas Gulf	1975	Seal Bay	8	1, 104.9
19*	Gullbridge Mines	?	Gullbridge	213	12, 473.9
25*	Consolidated Morrison	1976	Lake Bond	2	419.1
26*	L.M. & E.	?	Lake Ambrose	6	647.7
27*	Kerr Addison	1974-75	Victoria Area	5	655.3
28*	Shawmont	1977-78	Hinds Brook	28	822.9
29*	Advocate	?	Priests Showing	8	774.8
30*	Advocate	?	Nippers Harbour	7	946.1
31*	Advocate	1976	West Pond	3	144.7
32*	Advocate	1975	Flatwater Pond	11	907.6
33	ALCAN	?	St. Lawrence	?	8 ,153.4
34	David S. Robertson	?	Mt. Margaret Area	?	4, 463.8
35	David S. Robertson	?	Lawn Area	?	
36	Noranda	?	Round Pond Area	?	?
			TOTAL.		47 ,151.3 m

* collected in 1980

MINERAL DEVELOPMENT DIVISION

B.A. GREENE, Director

DOREEN PEAVY, Secretary to the Director

ADMINISTRATIVE SUPPORT SERVICES

D. WAYNE RYDER, Senior Administrator
SIDNEY PARSONS, Administrative Assistant (Nfld.)
JAMES BARRETT, Stockhandler
WAYNE TUTTLE, Administrative Assistant (Lab.)
TERRENCE YOUNG, Accounts Clerk

DRAFTING SERVICES

KENNETH BYRNE, Drafting Supervisor
WINSTON HOWELL, Cartographer
TONY PALTANAVAGE, Cartographer
DAVID LEONARD, Cartographer
WILLIAM CLARK, Cartographer

ENVIRONMENTAL GEOLOGY SECTION

DOUGLAS G. VANDERVEER, Senior Geologist
BYRON SPARKES, Project Geologist
FREDERICK KIRBY, Project Geologist
RANDY RICKETTS, Project Geologist
DANIEL BRAGG, Lithologist
MARTIN RICKETTS, Geologist

GEOCHEMISTRY SECTION

PETER H. DAVENPORT, Senior Geochemist
A. JAMES BUTLER, Project Geochemist
JOHN W. McCONNELL, Project Geochemist
HANK A. WAGENBAUER, Analytical Geochemist
CHARLES A. RILEY, Geochemical Analyst
S. CATHERINE SPURRELL, Labratory Assistant
CHIRSTOPHER J. FINCH, Laboratory Assistant
GEOFFREY DAWE, Laboratory Assistant
BEVERLY THOMPSON, Laboratory Assistant
ANNE MARIE BOURGEOIS, Laboratory Assistant

LABORATORY

AUDREY LEE, Director
EWART BURKE, Minerals Analyst
HERBERT SKANES, Minerals Laboratory Technician

LABRADOR MAPPING SECTION

RICHARD J. WARDLE, Senior Geologist
A. BRUCE RYAN, Project Geologist
CHARLES GOWER, Project Geologist
JOHN HILL, Project Geologist
ANDRE THOMAS, Project Geologist
GES NUNN, Project Geologist

MINERAL DEPOSITS SECTION

PAUL L. DEAN, Senior Geologist
AMBROSE F. HOWSE, Project Geologist
HARJIT MISSAN, Project Geologist
H. SCOTT SWINDEN, Economic Geologist
ALVIN HARRIS, Mineral Inventory Geologist
JOAN BURRY, Mineral Inventory Geologist
JEAN HILL, Mineral Inventory Geologist
TRUDY PARSONS, WP Operator

NEWFOUNDLAND MAPPING SECTION

W. RONALD SMYTH, Senior Geologist
R. FRANK BLACKWOOD, Project Geologist
LESLEY CHORLTON, Project Geologist
STEPHEN P. COLMAN-SADD, Project Geologist
JAMES HIBBARD, Project Geologist
RICHARD HYDE, Project Geologist
BAXTER F. KEAN, Project Geologist
IAN KNIGHT, Project Geologist
SEAN O'BRIEN, Project Geologist
LAWSON DICKSON, Project Geologist

PUBLICATIONS AND INFORMATION SECTION

REX V. GIBBONS, Senior Geologist and Editor
CYRIL F. O'DRISCOLL, Review Geologist
NORMAN MERCER, Mineral Exploration Consultant
CATHERINE M. PATEY, GEOSCAN Geologist
CELESTINE COLLINS, Drill Core Geologist
BRUCE BURT, Geological Technician
DEBORAH DOWNEY, WP Operator/Programmer
BRENDA DOYLE, WP Operator
CAROLYN GULLAGE, Typist
ELAINE HUTCHINGS, Typist
RANDY MEEHAN, Publications Clerk
BRIAN FLEMING, Microfiche Assistant
EUGENIE POWER, Librarian